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HISTORY OF SCIENCE.—*Ferdinand Hassler's gift to America.*

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*** In ridicule and humiliation he pursued his goal of giving the people of his adopted land a service of lasting value; however his true gift was not the labors to which he sacrificed himself, but the spirit and ideals still cherished by his followers.

It was not common in Ferdinand Hassler's day for public officials to argue with the President about their salaries, but Hassler was no common man. He was a genius who gave life to two of the country's most honored scientific services a century and a half ago, and he wanted to be paid accordingly. When he asked President Jackson in 1836 for $6,000 a year, he was rebuked—this was as much as his superior, the Secretary of the Treasury, received. To this Hassler had a scornful and to him a perfectly logical reply—Secretaries of the Treasury could be found anywhere, and could by made by any President, whereas there was but one Hassler. Only God Almighty could make a Hassler! He got the money, and the country got two scientific bureaus, the Coast and Geodetic Survey and the National Bureau of Standards, which still operate under a code of ethics that cannot be evaluated in dollars.

America, still young at the turn of the nineteenth century, was seeing a tremendous maritime growth. Almost all commerce was by coastal shipping, and 60,000 vessels of that trade sustained crippling losses because they had no charts of the coast. America's growth was threatened. When Congress faced up to this situation in 1807 by authorizing a survey of the coast, Ferdinand Hassler was the only man in America with the technical knowledge to undertake the work. Thus he became its first head, on the recommendation of the American Philosophical Society, after submitting the best of several plans for the work.

Hassler was born in 1770 of a prosperous watchmaking family of Switzerland. His early interest in mathematics and astronomy brought him to Johann Tralles, a leading geodesist who was applying the principles of higher surveying to the mapping of Switzerland to promote better land utilization and development. Among the problems facing Tralles and his pupil was the development of precise instruments and measurement standards, preoccupations that made Hassler a lifelong instrumentalist. Out of such beginnings grew his passion for precision and orderly procedure. Raised in affluence, he never developed a money sense, nor practical attitudes toward life's problems. He had a studious appearance with penetrating eyes. He never wore glasses—instead he became a habitual snuff user, "to stimulate the optic nerve" as he said.

In his scientific development young Hassler traveled widely, never hesitating to present himself to such eminent scientists as Lalande and Lavoisier, and to leading philosophers and historians. This self-assurance—impertinence in a lesser man—became a lifelong trait. He made a uniformly favorable impression, gaining a prestige in Europe that was lacking later in the relatively rough society of early America.

In the last years of the century political troubles interfered with the work he liked, and led him into public affairs. He displayed

original and constructive ideas in administration and education, and became Attorney General of Switzerland. Life, however, was distasteful, leading him to emigrate to America with his family in 1805. He dreamed of America as a refuge where he could farm in ease and comfort, indulging in reflection and study. He even organized a colonizing scheme and brought with him 120 immigrants to form a new community. Unfortunately, financing all this led him into commitments with associates who not only brought the scheme to grief—they also lost much of his fortune for the young crusader, and ruined his farming dream.

With him Hassler brought furniture, art objects, standards of weight and measure, and a library of 3,000 volumes on all aspects of natural science as then known. That collection, brought for his personal satisfaction, was destined later to be sold, little by little, during long periods of reversal, but this was not at first apparent.

He promptly obtained citizenship, and got in touch with scientific men, who were captivated by his sincerity and earnestness, his five languages and cosmopolitan air, the novelty of his library, and by his donation of scientific curiosities to the American Philosophical Society. Among his new friends were Prof. Robert Patterson, director of the Mint, who recommended him to President Jefferson for a job as surveyor or astronomer, and John Vaughan, a public-spirited Philadelphian, who also wrote Jefferson of "one of the most interesting foreigners we have for a long time had among us."

Jefferson, who liked to read scientific papers before learned societies, and who looked on science as the cornerstone of the Republic, quickly became a friend of the young Swiss. This association, and the urgings of Patterson and Vaughan, led to an executive recommendation resulting in a Congressional authorization of $50,000 for a survey of the coast.

Hassler's plan for the work was based on simple logic. Starting from astronomical positions of "remarkable" points of the coast and a triangulation survey to join them in a rigorous system of control, he would then—and only then—make a nautical survey of the shoals and coastal waters. If Hassler had any clear conception of the enormous size of this undertaking, he did not advertise it. Certainly Congress thought the matter would soon be concluded, and felt the money appropriated to be liberal in the extreme.

Hassler, to support himself, had meanwhile taken a $1,500 professorship of mathematics at West Point that was to last three years while the Administration temporized over starting the survey. There he began a text which displayed a new analytical approach to the study of trigonometry. He wrote a paper on meteorites, and he observed a comet "of extreme beauty." He was widely admired, and he made friends among students who later became his aides on the survey and lifelong supporters. He spent much time preparing detailed plans of instruments and procedures, and in writing letters urging haste upon the administration.

In 1810, despite protest earned by his stimulating teaching methods, he was forced out of West Point by a ruling that the Army lacked authority to employ civilian teachers. He left a sundial on a rock near the house he had occupied, like one he had placed as a boy in his native town in Switzerland. It remained many years. He next took an appointment at Union College, which, though it lasted but a year, left such an impression that the president of the college could say, in 1843 at Hassler's death, "We have not such another man to die." His impoverishment during these years of low salaries meant little to Hassler, who sold his books one by one, living for the day when his great work would begin. His wife, who loved society and fine living, found it a dismal period.

Early in 1811 Treasury Secretary Gallatin found it possible to proceed, and Hassler joyfully left Union College to begin the survey. He had previously written that the work could not be done without tools—and none were available in America. In his words, "Good instruments are never to be obtained by buying in shops, where only instruments of inferior quality are put up to sell; they must be made on command, and by the best mechanicians (of London)." So it was that he went to Europe to procure the theodolites and other instruments, and

FERDINAND HASSLER

to find copper for the chart engravings—indeed the engravers themselves would have to be recruited in Germany.

He had new instruments of his own design built in London, including a revolutionary "great theodolite" for measuring angles of the survey. He collected reference books, new standards of measurement, and other necessities, and he visited the continent to discuss his plans with leading scientists. All this forced delay, particularly since war intervened, and the mission lengthened into years. In his zeal he personally paid obligations of the United States, and of his official funds he overspent the $50,000 allowed him by Congress. This brought severe censure, and he had to return home at his own expense—bringing to America a collection of instruments said to be the best ever to leave England.

Actual operations were delayed still further for many reasons, including lack of funds, until 1816. Then he was finally appointed superintendent, with a salary of $3,000 and an expense allowance of $2,000—not enough for the improvident Hassler, who had to continue drawing on his own resources, finally going to the President with his money problems. He later reported, "I resigned the certain and respectable position of professor . . . at Union College . . . to embark in a work in which the disagreements and pecuniary losses have by far exceeded my compensations."

The first work in the field was in preparation for surveying the area about New York. Instrument supports were built before the actual appropriation of funds. Practically at the outset, arrangements for the measurement of a baseline near Long Branch were interrupted by the first of a long series of controversies—in this case a lawsuit about branches of a cedar bush used as a survey signal. Hassler had to ask for papers of public authority.

Hassler constructed a carriage ingeniously arranged to safeguard his "great theodolite" in transit, as well as to provide compartments for books and papers and personal conveniences. This effective but strange conveyance attracted great attention, doubtless contributing to Hassler's growing reputation as an eccentric. Congress was never reconciled to the expenditure of official funds for such a monstrosity. In early 1817, before a year had passed, Hassler was asked by the Secretary of the Treasury for an estimate of the time and cost of completion of the project! The communication hinted of Congressional impatience and the possibility of action to terminate the project.

This was preposterous! He was hardly begun! Clearly Washington was utterly ignorant in such matters, so he tried to explain. Much preparatory work had to be done. A precise geodetic survey based on astronomic observations must precede the nautical survey. The chart must show all details of the shoreline and the landmarks, requiring laborious operations along every bit of the coast. All this must come first. Hassler worked desperately to impress Congress. He told how diligent he had been: "I protracted the summer work till the end of December, when none about me thought it possible to stand it any longer for cold . . . I have been up and at observations with or before sunrise . . . taking out the results occupied me commonly till about eleven o'clock at night. All this was witnessed enough by every person about me."

Notwithstanding all his efforts, he could not satisfy Congress. Where he meant to build for the future, and to add lustre to American science, Congress wanted to satisfy the needs of the moment, and cheaply too. On April 14, 1818, a bewildered and uncomprehending Hassler was thrown out. There began a long period while Congress tried to get along without him—a period of almost complete inactivity. Shipwrecks continued!

Hassler, misunderstood and neglected, prepared a long paper of self-justification, later published by the Philosophical Society which gained him favorable attention, at least in Europe. Included was a brilliant proposal for the use of a polyconic projection for survey use in the technically difficult problem of portraying the curved earth on flat maps—a tool so perfect that it remains in use today.

It was not long until another short-lived assignment appeared, in 1818, for which no one else could be found—an appointment as astronomer with the Commission demarking

the Canadian boundary eastward from the St. Lawrence River, as ordained by the Treaty of Ghent. He repurchased and repaired the famous carriage at a personal loss of $1,200. The first running of the line seemed to indicate the loss to Canada of a one-mile strip of farmland, containing two newly built United States forts. The farmers became incensed, apparently in distrust of Hassler's foreign origin and thick accent. He feared personal violence, but his technical skill did not fail him. He propounded a new geodetic interpretation based on the lately discovered ellipticity of the earth. After protracted quarreling, he carried his point, and saved the disputed land for the country. This done, he left the boundary survey in a dispute over his salary and in humiliation over criticisms by the commissioner, who quite correctly but perhaps rudely called him quarrelsome. Thus Hassler went into a long eclipse.

During a 10-year period he had to support himself as best he could. He wrote textbooks which earned him nothing, but which contained innovations of mathematical development. He lost teaching opportunities because it was fashionable to employ famous "continental" professors. His resources exhausted, he tried farming, in pursuit of his dream of earlier years, but again he was cheated. He got no decent farm buildings, and he could not farm, but he lost his wife, who could not stand the isolation of country life. Disconsolate, dejected, and desperate, he sold more of his books, then he took menial jobs. But he never lost faith that one day he would return to his project. A more determined man has seldom lived than Ferdinand Hassler. He refused a flattering offer to go to Russia, saying that, though not paid in money, he would accomplish an invaluable labor for the American Republic that would never perish.

Finally, in 1830, Hassler received a commission that brought him back to public life, and led, through a series of unauthorized acts on his part, to the second of his great works for America—a service that eventually became the National Bureau of Standards. His fanatic devotion to the cause of correct measurement was well known—more significant, perhaps, was his possession of the best such standards in America. Congress, feeling that the nation's international trade was in jeopardy because of the different concepts of pounds and bushels entertained by the various collectors of customs, ordered sets of standards to be furnished them—a good enough idea, but there were no standards! Treasury Secretary Ingham thereupon, on request of Congress, assigned Hassler to inspect and review the measures used in the customhouses.

Much of man's great advance in civilization has derived from his ability to measure —thus he learned to build, to navigate, and to trade. This early intellectual attainment had been so prostituted since the dawn of history, however, as to threaten the orderly development of commerce and industry. Standards were crudely defined, and lacked uniformity. Chiseling and cheating were rampant.

Biblical injunctions for the use of righteous measures are many. Parliament, and later Congress, struggled with the problem through the centuries. George Washington pleaded for reform of weights and measures, but the interests of unprincipled merchants were too strong. In 1830 the sole official "standard" in the States was a copy, in a vault of the Treasury, of a yard-long brass rod established in Britain by the monarch about 1600, and later found to have been broken at an unknown time.

Hassler instinctively despised any misuse of standards—probably he also appreciated the practical value of correct measures, whether for a yard of ribbon or a coastline. If Congress lacked initiative to enforce correct standards, not so Hassler! The terms of his commission meant vastly less to him than the demands of the situation. Without further ado, he set up shop, announced and promulgated standards, made and distributed copies, and entirely without authority he constituted himself Superintendent of Weights and Measures. Far from confining himself to the customhouses, he extended his authority to all the Government departments—even to the states. Congress, eventually discerning what was going on, and presumably relieved to be rid of the responsibility, urged him to hasten! In 1836 a resolution directed the Treasury Secretary to

do what Hassler had already done, and to use all the weights and measures already established as standards—established, that is, by Hassler! This achieved a stability that a thousand years of effort had not found.

The results were far-reaching. Hassler's weights and measures were copies, as precise as could be made, of those in England, and it was America's singular privilege, upon the burning of Parliament in 1843, to make England a present of new ones copied from Hassler's copies! The Office of Weights and Measures, child of Hassler's initiative, remained in the office of Superintendent of the Coast Survey until 1901, when the National Bureau of Standards was formed. Much of the American story of technological advancement, mass production methods, and flourishing business based on trust in honest measures, has been directly due to Hassler's work and to the honest and objective scientific work since carried out by the Bureau of Standards in keeping with his traditions.

Successful public service in connection with standards earned him a measure of public esteem, so that Congress, long since dismayed at the lack of progress on the survey of the coast, finally authorized Hassler's reinstatement. This appointment was to last the rest of his life. On this occasion the Astronomical Journal saw fit to announce, "The editor cannot omit herewith to present to the Government of the United States his thanks, in which all men who take an interest in exact sciences will join him, for having taken up again this beautiful work, that had been begun by Mr. Hassler sixteen years ago. This work could certainly not be executed better by any other man than him, who in its beginning had already shown so much talent."

Operations began about 1832. Known in midcentury as the "Coast Survey," the bureau eventually became the "Coast and Geodetic Survey" when the nation-wide geodetic surveys started so painfully by Hassler in 1816 became recognized by engineers and mappers as fundamental to their work. In its long history the Survey has established procedures looked on as definitive the world around, yet it has remained small and little-known except to those it directly serves—doubtless as Hassler would have wished.

The years of his later period were stormy. Among his high-handed practices was the witholding of charts needed by mariners until he could personally verify them. He remained proud and intolerant, drawing down antagonism on himself by his unconcealed scorn of official interference. In his code only scientists could evaluate the work of scientists. When an investigating committee of Congress visited him, he sent them away with scathing denunciations of their presumption—giving rise to mirth in Congress, but little in the way of financial support. This irascible man, nevertheless, brought hardened political and public opinion to his support in the end.

By 1835 a foundation of survey control in the New York area permitted start of hydrographic work. The schooner *Experiment* and the brig *Washington* were the first of a long line of survey ships that were to sail across the unknown seas that were to become vast indeed with the growth of the Republic. The labors of these sailing craft were plodding and slow, but to Hassler and all American mariners they represented the first fruits of the work authorized 28 years before.

Everyone was impressed—even Congress—when many rocks and ledges were brought to light in the nearby waters of Long Island Sound. A dramatic discovery was the Gedney Channel approaching New York from the southeast by Sandy Hook, which gave rise to the interesting speculation that had the friendly French fleet known of it in 1778, a coup of major importance might have been executed against the British ships within.

Hassler lived to see the first surveys done between Rhode Island and Delaware Bay, and the country soundly embarked on the course he had set, and his work appreciated. Some years after his death Sir R. I. Murchison characterized the Survey, before the Geographical Society of London, as "one of the most perfect exemplifications of applied science in modern times." In 1879 Martha Lamb could say, in the language of the day in Harper's Magazine, "In human progress within the present century there is no

greater marvel than the operations of the Coast Survey."

All his life Hassler fought short-sighted men eager for quick, cheap results, heedless of lasting values. He won, teaching America some of the fundamental things we now take for granted. Science is based on truth and orderly development of ideas, not on short cuts. It is not political nor sectional, but universal and fundamental. Morale and interest are essential, and the scientific worker deserves a fair living and honor—not easily come by in Hassler's time.

It may be doubted that America was ever served by a more consecrated man. No one could doubt it who could have seen him night after night in his office, past midnight at a candle-lit table, checking computations, verifying charted soundings, or writing reports. He was doing work for which his appropriations did not provide workers, and seeing personally to the attainment of his own impeccable standards for the work.

When he could spare himself from the office, or from the incessant demand of Congress for explanations, he endured the hardships of travel and field life, personally to perform the more important observations. In 1843, during a storm, Hassler, trying to protect one of his cherished instruments from the elements, fell in the darkness, injuring himself on a projecting rock. Aged 73 years, and weakened by a lifetime of relentless work, he died from this mishap. He died in pursuit of his vision, probably little realizing how long enduring his example would be. In 1957, the one hundred and fiftieth anniversary of the survey of the coast, the realization became vivid indeed!

INTERACTION OF DIRECT AZO DYES IN AQUEOUS SOLUTION

National Bureau of Standards research on the properties of materials is providing evidence of a fundamental relationship between the attachment of direct azo dyes to cotton and the chemical association of these dyes in mixtures.[1] The correlation results from a current study of spectral changes of organic dyes as caused by light, heat, and concentration variables. Partially sponsored by the Air Force Office of Scientific Research, the program is being conducted by J. H. Gould and M. N. Inscoe of the NBS staff in collaboration with W. R. Brode, Associate Director of the Bureau. While the results apply primarily to changes in solution, they may provide a valuable basis for further investigations of dye adherence to fabrics.

Direct, or substantive, azo dyes have a strong affinity for cellulose and adhere directly to the fibers when applied from a boiling neutral solution. This is important in the textile industry since cotton is 99 percent cellulose and since the structure of rayon is also based on this fundamental molecule.

[1] For further technical information, see *The relation between the absorption spectra and the chemical constitution of dyes.* XXIX, *The interaction of direct azo dyes in aqueous solution,* M. N. INSCOE, J. H. GOULD, M. E. CORNING, and W. R. BRODE, Journ. Res. NBS **60**: 65. 1958. RP 2823.

The behavior of direct dyes applied from dye baths containing mixtures of dyes often differs from that of the individual dyes. In general, the altered characteristics are attributed to interaction or complex formation between unlike molecules and include an increase in time to reach equilibrium, a decrease in the amount of one or both of the dyes absorbed at equilibrium, or a greater unevenness in the dyeing.

When the absorption spectrum of a mixture of azo dyes in aqueous solution is not the same as the sum of the spectra of the individual components in separate solutions, the result is called a "non-additive" spectrum. Because the absorption curve is an inherent characteristic of the dye molecule, nonadditive spectra are indications of interaction. No spectral changes were noted when aggregation occurred at the concentrations used in this study. Aggregation is defined here as the complex association of like molecules.

In the present experiments, 30 direct azo dyes differing in aromatic components, number of azo groups, and arrangement of substituents were studied in various combinations. To insure solubility in a water solution, all of these dyes were sulfonic acid (—SO_3Na) derivatives.

To obtain the graphic addition spectrum of two individual dyes, the two dyes in separate solu-

tions were measured simultaneously in the spectrophotometer. Then, the same components were mixed and remeasured. If this latter spectrum was not the same as the initial spectrum, it was assumed that interaction had taken place.

Although mixtures of direct dyes usually gave nonadditive spectra, there were two general situations in which additive spectra were obtained instead of the expected nonadditive curves. In the first of these, the steric hindrance by central sulfonic acid groups prevented interaction between the two dyes. This effect is caused either by the bulkiness of the acid groups, which could interfere with the close approach of the molecules of the dyes, or by the mutual repulsion between the like negative charges, which could also hinder the molecules from drawing near each other. Additive spectra were also noted when the terminal groupings on both components were identical or very similar. It is probable that interaction may occur in such cases but does not produce marked spectral changes because of the similarity between the two dyes. Interaction in such a mixture is comparable to aggregation in a solution of the individual dye, and the degree of aggregation does not produce significant anomalous behavior with direct azo dyes.

The acid azo dyes, as opposed to the direct azo dyes, do not adhere directly to cotton nor are they appreciably aggregated at higher concentrations or by inorganic salts. An acid dye generally contains a shorter conjugated chain (alternating double and single bonds) than does a direct dye. The repulsion of the negatively charged sulfonic acid groups on the molecule and the increased solubility caused by these groups are effective in keeping the molecules separated. Because of these factors, the dyes show little tendency toward interaction in mixtures with the direct azo dyes.

Basic dyes, e.g., methyl violet or methylene blue, as well as some substantive fluorescent brightening agents, were shown to give nonadditive spectra in mixtures with various other dyes.

The presence of foreign substances in the dye solution influences the state of aggregation of the dyes as well as their behavior in dyeing. The addition of inorganic salts increases aggregation of the dye as well as the amount of dye taken up by the fiber. Other substances may have an opposite effect. For example, pyridine inhibits the aggregation of azo dyes and also decreases the affinity of these dyes for cellulose to such an extent that it can be used as a "stripping" agent to remove the dye from the fiber. Such substances also influence the interaction of azo dyes in mixtures.

Alcohol and non-ionic detergents—both effective in decreasing the aggregation of direct azo dyes—prevent interaction. Mixtures of dyes that normally give nonadditive spectra gave additive spectra in solutions containing 40 percent alcohol or 0.1 percent of a nonionic detergent. On the other hand, the addition of inorganic salts or a large increase in the dye concentration produced spectral changes which indicated greater association between the dyes.

A naturalist's life would be a happy one if he had only to observe and never to write.—CHARLES DARWIN.

ZOOLOGY.—Antillesia cardisomae, *n. gen. and sp.* (*Copepoda: Harpacticoida*) *from the gill chambers of land crabs, with observations on the related genus* Cancrinola. ARTHUR G. HUMES, Boston University. (Communicated by Fenner A. Chace, Jr.)

(Received July 22, 1957)

Harpacticoid copepods living in the gill chambers of land crabs have been described from Jamaica and Louisiana, but little is known about these parasites in other regions of the Gulf of Mexico and the West Indies. Several persons, acknowledged below, have kindly supplied me with copepods from crabs of the West Indian and Gulf regions. Additional specimens have been recovered from crabs in the collection of the Museum of Comparative Zoology at Harvard University. This has made possible a redescription of certain features of *Cancrincola jamaicensis* Wilson and *C. plumipes* Humes, and the description of the new genus and species below.

This study was aided by a grant from the National Science Foundation.

Cancrincola jamaicensis Wilson, 1913

This species was described from specimens taken from the gill chambers of *Cardisoma guanhumi* Latreille at Montego Bay, Jamaica. Since certain inadequacies and discrepancies exist in the original description, the type specimens were sought for study. Unfortunately, the type, U.S.N.M. no. 43506, has disappeared from its vial and can not be located. The paratypes, U.S.N.M. no. 32596, have dried up and are useless for study.

Other specimens of *C. jamaicensis* have been mentioned in published papers or listed in museum collections, but these are probably not very reliable. Dr. A. S. Pearse collected copepods from *Cardisoma guanhumi* on July 15, 1931 (U.S.N.M. no. 69804) at Key West, Fla. These specimens, which he identified as *C. jamaicensis*, have unfortunately become dry and are of no use for study. On August 2, 1931, he found two copepods in *Paguristes punctipes* Benedict at Loggerhead Key, Tortugas, Fla. These, U.S.N.M. no. 69811, are labeled *C. jamaicensis*. I have studied them and find that they do not belong to the genus *Cancrincola*, perhaps being accidentally present. On July 1, 1931, Dr. Pearse found copepods (U.S.N.M. no. 69807) in the gill chambers of *Microphrys bicornutus* (Latreille) at Tortugas, Fla. These were identified by him as *C. jamaicensis* and are the specimens referred to by Wilson (1935) as living in this crab. I have examined the single specimen remaining in the vial and find that it is not a *Cancrincola* but rather another copepod accidentally present. Pearse (1951) listed *C. jamaicensis* from *Gecarcinus* sp., *C. guanhumi*, and *Panopeus herbstii* H. Milne-Edwards at Bimini, Bahamas. I have studied a specimen (U.S.N.M. no. 88572) from his *Gecarcinus* and find that it is neither *Cancrincola* nor the new genus to be described below. Other specimens (U.S.N.M. no. 88571) from his *Cardisoma* are not *Cancrincola* but belong instead to the new genus to be described on subsequent pages.

Because of the mistaken identity of these copepods, casting doubt on the identification of Pearse's now dried specimens from Key West and those from *Panopeus* at Bimini, it seems best to discount all records concerning *C. jamaicensis* in the preceding paragraph. The only well-substantiated New World record to date is Wilson's original collection at Montego Bay, Jamaica, made in the summer of 1910.

Oswald N. Morris has sent me a single female *Cancrincola* taken from the gill chambers of a *Cardisoma guanhumi* collected on March 23, 1957, on the banks of the Barnett River near the Bogue Islands, Montego Bay, Jamaica. This specimen may be considered as a topotype. It measures 0.684 by 0.156 mm, and the measurements of leg 1 are: length and width of the first podomere of the endopodite 73 by 14μ, length of the inner seta 61μ, length of the second podomere 24μ, and length of the exopodite 59μ.

Dr. Peter F. Bellinger, of the University College of the West Indies, has sent me harpacticoid copepods from *C. guanhumi* taken in November 1955, and again in February and May 1956, on the mud flats at Port Henderson, St. Catherine, Jamaica. One of the two species in these lots resembles in all major respects Wilson's *C. jamaicensis*. Although these can not be con-

sidered as topotypes, they come from the same island and from the same host crab. In the absence of type specimens or other comparative material and in view of the desirability of clarifying certain points in the original description, selected features of these *C. jamaicensis* from Port Henderson are described here.

Female.—The total length, including the caudal rami, based on five specimens, is 0.691 mm (0.624–0.815 mm). The greatest width of the thorax is 0.146 mm (0.144–0.150 mm). The aesthetask on the fourth podomere of the first antenna (Fig. 1) is 41μ long (39–43μ), based on seven specimens, tapering smoothly in its distal half, with no constriction. The single egg sac contains 10 eggs (8–13, based on 10 specimens). The average measurements, based on three specimens, of leg 1 (Fig. 2) are: length and width of the first podomere of the endopodite 73 by 14μ, length of the inner seta 62μ, length of the second podomere 22μ, and length of the exopodite 63μ.

Leg 5 (Fig. 3) lacks the minute setae on the margin of the inner expansion. The lengths of the long setae on the inner expansion of the basal podomere and on the distal podomere are as follows (beginning with the outermost):

Distal Podomere				
20μ	52	33	56	92
18–21μ	48–55	31–35	53–57	90–96
Inner Expansion				
52	85	33	29	22
48–57	80–88	32–34	28–31	21–22

Instead of the condition described by Wilson, the armature of the caudal ramus is like that to be described below for *C. plumipes*, the armature of the second antenna corresponds to that of *C. plumipes*, and the armature of legs 1 and 5 is as indicated in Figs. 2 and 3. One may presume that these minute discrepancies are errors in the original description.

In Wilson's original description of *C. jamaicensis* the female is 0.8 by 0.175 mm and the male 0.88 by 0.17 mm, measurements somewhat larger than my measurements of Jamaican specimens. The length of Wilson's female falls within my size range, however. His male is larger than any that I have found. Furthermore, his male is even larger than the female, a condition not observed in any of the species of *Cancrincola* which I have studied. The size differences may be caused by Wilson's measurements having been made on fresh and uncontracted specimens.

Male.—The total length, including the caudal rami, based on three specimens, is 0.629 mm (0.586–0.715 mm). The greatest width of the thorax is 0.136 mm (0.134–0.140 mm). The first antenna has a small terminal hook. The aesthetask on the fourth podomere is 52μ long (50–57μ, based on seven specimens). Leg 3 (Fig. 4) has a relatively short middle seta on the end of the endopodite. Leg 5 (Fig. 5) has either five or six setae. If six, the two outermost are distally plumose, the next three setae are situated on the end of a small lamella, and the innermost is on a short pedicel. If five (Fig. 6), only two setae are on the lamella. A minute peglike projection is often visible, though sometimes only with difficulty, on both sides of the lamella.

Other specimens of *C. jamaicensis* have been sent to me from St. James, Barbados, by John B. Lewis, of the Bellairs Research Institute of McGill University. They were taken in November 1955 from *Cardisoma guanhumi*.

Dr. Robert L. Blickle has sent me specimens of *C. jamaicensis* collected on May 24, 1957, from *C. guanhumi* at Vero Beach, Fla.

Through the courtesy of Dr. Dorothy E. Bliss I have collected *C. jamaicensis* from the same host crab sent to her from the Lerner Marine Laboratory of the American Museum of Natural History at Bimini, Bahamas. Although several specimens of *Gecarcinus lateralis* (Freminville) from the same locality were examined, no copepods were found, in spite of the *Cardisoma* in the region being heavily parasitized.

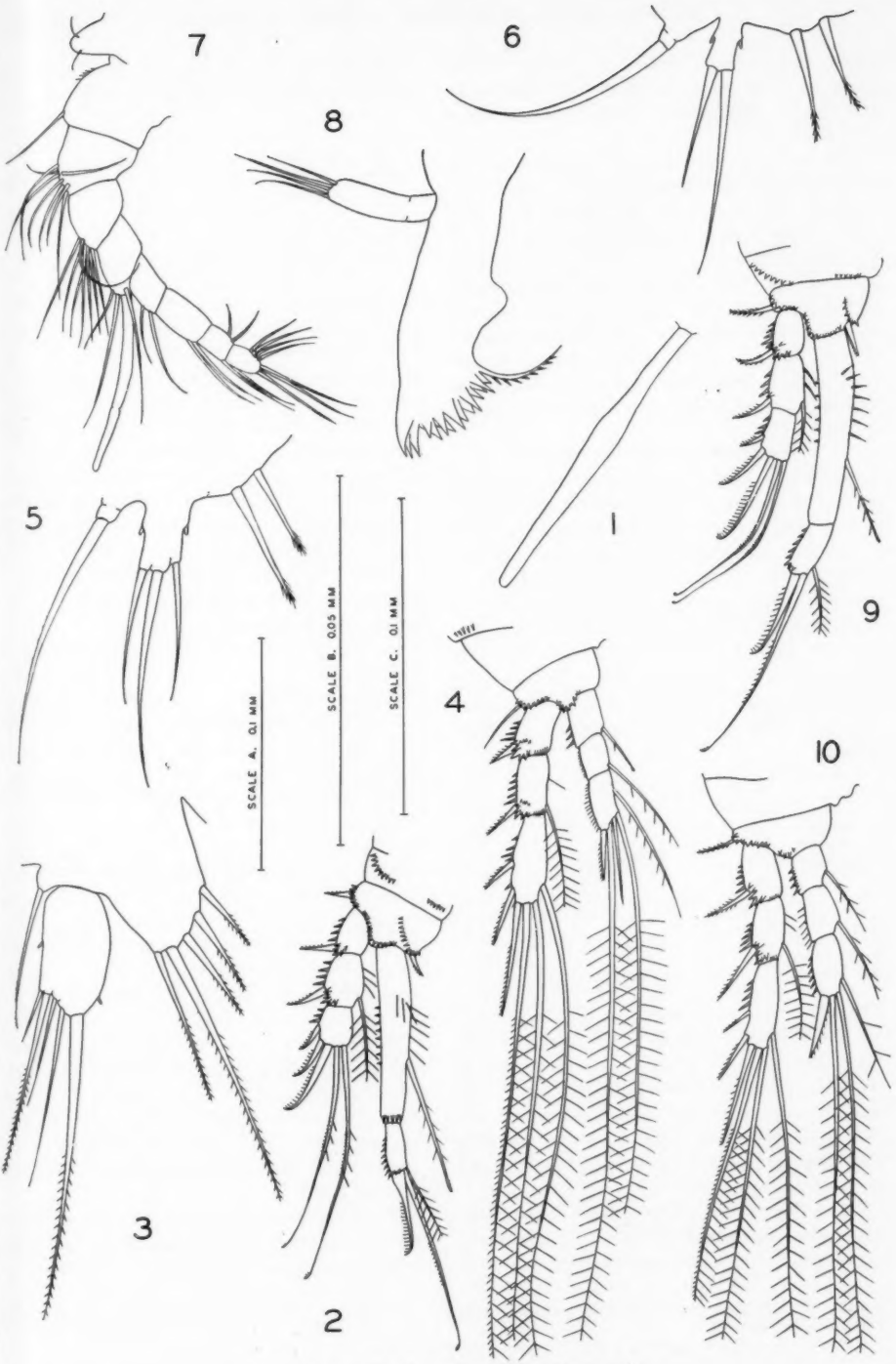
Specimens of *C. jamaicensis* were washed out of the gill chambers of *Cardisoma guanhumi* in the collection of the Museum of Comparative Zoology at Harvard University. The crabs parasitized were from Cannavieiras, Brazil (M.C.Z. no.

All figures were drawn with the aid of a camera lucida. The letter following each figure title refers to the scale at which the figure was drawn.

Figs. 1–3.—*Cancrincola jamaicensis* Wilson, female: 1, Aesthetask on the first antenna (B); 2, leg 1 (A); 3, leg 5 (C).

Figs. 4–6.—Same, male: 4, Leg 4 (A); 5, leg 5 (B); 6, leg 5 (B).

Figs. 7–10.—*Cancrincola plumipes* Humes, female: 7, First antenna (C); 8, mandible (B); 9, leg 1 (A); 10, leg 2 (A).



FIGS. 1.–10.—For legend see opposite page.)

5609), Pernambuco, Brazil (no. 5610), Grand Anse, Haiti (no. 5602), St. Kitts (no. 5604), Swan Island (no. 8659), and Bahia Honda, Cuba (no. 5601).

The known distribution of *Cancrincola jamaicensis* is shown on the accompanying map. The copepod probably occurs throughout the range of the host crab, *Cardisoma guanhumi*, which Rathbun (1917) gives as "Bahamas, Southern Florida, West Indies, Texas to São Paulo, Brazil, and Bermudas." The copepod parasitizes *Cardisoma armatum* Herklots and *Sesarma huzardi* (Desmarest) in West Africa, where Humes (1957) reported it from several localities from Dakar to Pointe-Noire, as indicated on the map.

Cancrincola plumipes Humes, 1941

Several hundred topotypes were collected from the gill chambers of *Sesarma reticulatum* (Say) in July 1941 at Grand Isle, La. Since the original description inadequately mentions certain features, supplementary notes are presented here.

Female.—The first antenna and the rostrum are as indicated in Fig. 7. The aesthetask is 52μ long (48–56μ) with a noticeable constriction in its distal half. The mandible (Fig. 8) has a weakly subdivided palp bearing four terminal setae. Legs 1–4 have the following spine and setal formula:

	leg 1		leg 2	
	exp	end	exp	end
1st podomere	1:0	0:1	1:0	0:1
2d podomere	1:1	3	1:1	0:1
3d podomere	5		6	4

	leg 3		leg 4	
	exp	end	exp	end
1st podomere	1:0	0:1	1:0	0:1
2d podomere	1:1	0:0	1:0	0:0
3d podomere	6	5	5	5

The average measurements (based on seven specimens) of leg 1 (Fig. 9) are: length and width of the first podomere of the endopodite 83 × 14μ (81–84μ × 14μ), length of the inner seta 42μ (41–43μ), length of the second podomere 22μ (21–23μ), and length of the exopodite 64μ (62–67μ). Legs 2, 3, and 4 are as shown in Figs. 10, 11, and 12, respectively.

Leg 5 (Fig. 13) has three minute peglike projections on the margin of the distal podomere. The lengths of the setae on the inner expansion of the basal podomere and the distal podomere are as follows (beginning with the outermost):

Distal Podomere				
19μ	38	28	51	116
18–20μ	30–49	26–31	43–56	105–128
Inner Expansion				
50	88	29	27	24
44–56	83–92	27–31	25–28	21–26

There are a few minute setae on the inner margin and the outer distal corner of the inner expansion.

The caudal ramus (Fig. 14) is short, its width greater than its length, with a single long terminal seta and smaller setae as indicated in the figure.

Male.—The first antenna (Fig. 15) has a small terminal hook and three pectinate setae as shown in the figure. Leg 3 (Fig. 16) has a relatively short middle seta on the end of the endopodite. The spine and setal formula of legs 1–4 is like that of the female. Leg 5 (Fig. 17) has five setae, the two innermost distally plumose, the next two on a lamella, and the outermost pedicellate. The abdomen is 4-segmented.

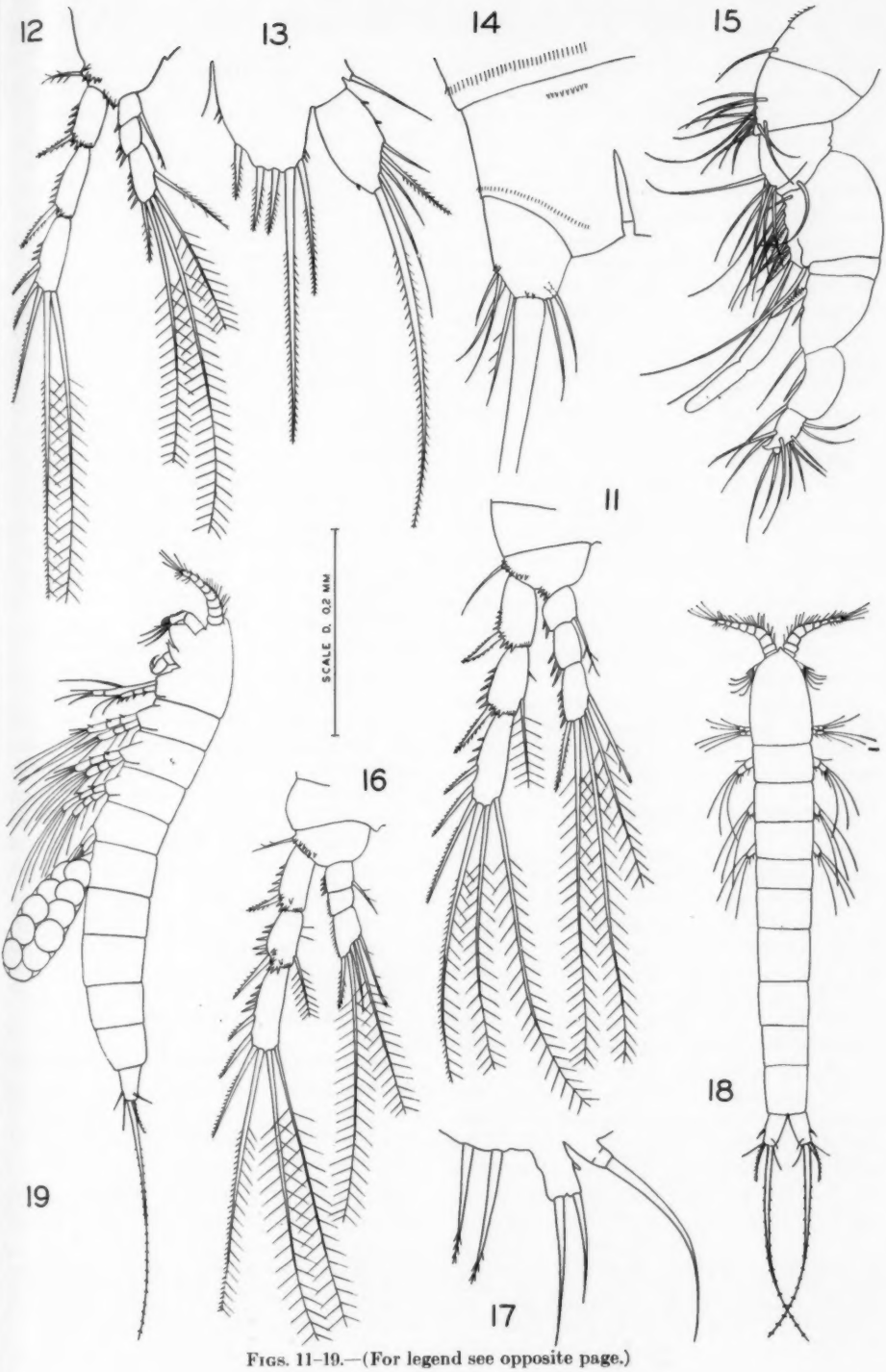
C. plumipes differs from *C. jamaicensis* in having a constriction in the distal half of the aesthetask on the first antenna, in the endopodite of leg 1 being relatively longer and its inner seta distinctly shorter, in having a few minute setae along the inner margin and at the outer distal corner of the inner expansion of leg 5 in the female, in the long setae on the inner expansion and distal podomere of leg 5 in the female being of somewhat different lengths, and in having two setae invariably on the lamella of leg 5 in the male.

Other specimens of *C. plumipes*, recovered from *S. reticulatum*, have been sent to me by Marvin Wass from Alligator Harbor, on the northwest coast of Florida.

This species was also recovered from washings of the gill chambers of *S. reticulatum* from Tiverton, Rhode Island (M.C.Z. no. 10936). The range of *C. plumipes* probably coincides with that of the host crab, which Rathbun (1917) gives as "from Woods Hole, Massachusetts, to Calhoun County, Texas."

C. plumipes has also been recovered from *Sesarma cinereum* (Bosc) at three localities. Over 100 copepods were found in the gill cham-

FIGS. 11–14.—*Cancrincola plumipes* Humes, female: 11, Leg 3 (A); 12, leg 4 (A); 13, leg 5 (C); 14, caudal ramus, ventral (C).
FIGS. 15–17.—Same, male: 15, First antenna (C); 16, leg 3 (A); 17, leg 5 (B).
FIGS. 18, 19.—*Antillesia cardisomae*, n. gen. and sp., female: 18, Dorsal (F); 19, lateral (F).



FIGS. 11–19.—(For legend see opposite page.)

bers of 19 of these crabs at Bears Bluff, Wadmalaw Island, S. C., collected in June 1957 by G. Robert Lunz. These specimens show the features distinctive of *C. plumipes* but are smaller. The average total length of 10 females is 0.549 mm (0.504–0.600 mm) and of 10 males 0.544 mm (0.504–0.576 mm). The measurements of certain parts are proportionately smaller: aesthetask on the first antenna of the female 48μ (42–53μ), first podomere of the endopodite of leg 1 of the female 71 × 14μ (64–78μ × 14μ), its inner seta 35μ (28–42μ), second podomere 22μ, exopodite of leg 1 of the female 60μ (53–73μ). The setae of the fifth leg of the female are: 17, 23, 24, 45, 107, 43, 72, 27, 24, and 23μ, respectively.

Two females from *S. cinereum* at Alligator Harbor, Fla., show variations in the spine and setal formula of the swimming legs. In both the exopodite of leg 1 is 1:0, 1:0, 5. The endopodite of leg 2 in one female is 0:1, 1:1, 3. Leg 4 in the other is 1:0, 1:1, 5 and 0:1, 0:1, 5.

Nine females and 2 males from *S. cinereum* at Jacksonville, Fla. (M.C.Z. no. 6208) conform closely to the specimens of *C. plumipes* from South Carolina.

Presumably the copepod occurs throughout the range of *Sesarma cinereum*, which Rathbun (1917) gives as "from Chesapeake Bay (Arundel-on-the-Bay) to Tampico, Mexico."

Cancrincola longiseta Humes, 1957

Specimens of this copepod, known previously only from *Goniopsis cruentata* (Latreille) in West Africa, were recovered from the same host crab at Caruca, Rio Maria, Brazil (M.C.Z. no. 6167), Victoria, Brazil (6164), Santa Clara, Rio Mucury, Brazil (no. 8777), Pernambuco, Brazil (no. 6165), Rio de Janeiro, Brazil (no. 6168), Panama (no. 6160), Jeremie, Haiti (no. 6159), and the Bermudas (no. 8730). Apparently the copepod occurs throughout the range of the crab ("Bahamas and Gulf of Mexico to Province of São Paulo, Brazil; Bermudas; West Africa," according to Rathbun, 1917). The accompanying map shows its known distribution, including the localities in West Africa cited by Humes (1957).

Antillesia, n. gen.

Body elongated, cylindrical. No operculum. Caudal ramus nearly three times longer than wide, bearing terminally an inner long seta and an outer, short, pectinate, recurved seta. Rostrum minute and rounded. First antenna of female 8-jointed, without plumose setae; aesthetask on fourth podomere. First antenna of male 7-jointed and slightly prehensile, but lacking a terminal hook. Second antenna with a single-jointed exopodite. Mandible with a 2-jointed palp. First maxilla, second maxilla, and maxilliped resembling in general those of *Cancrincola*.

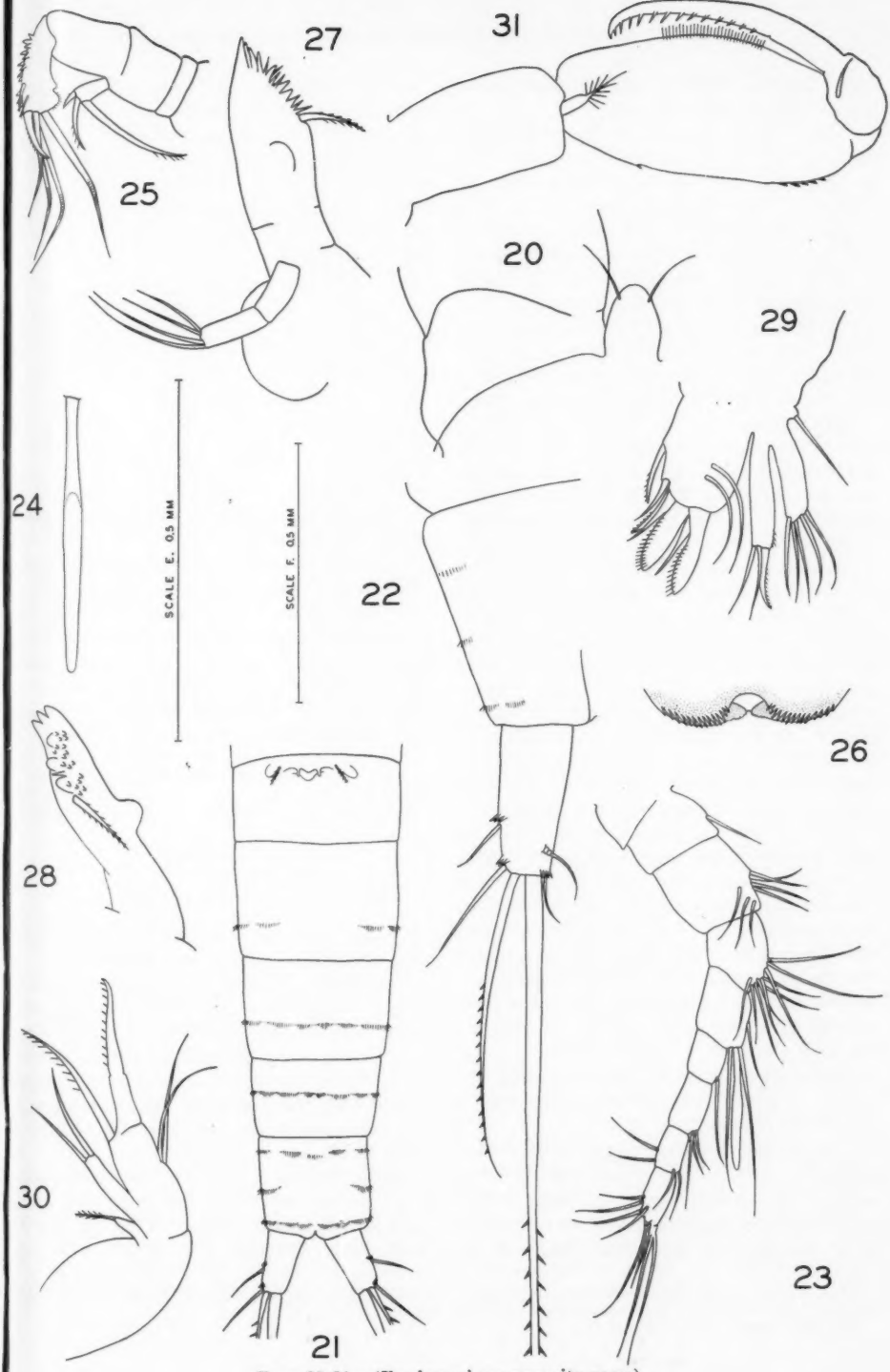
Leg 1 with a 2-jointed, prehensile endopodite distinctly longer than the 3-jointed exopodite. Both rami of legs 2, 3, and 4 three-jointed, the exopodites somewhat longer than the endopodites, with the spine and setal formula as given in the description below. Leg 3 in the male with next to outermost terminal seta of endopodite relatively very short. Leg 5 of the female with the basal podomere bearing five setae on the inner expansion and one outer seta, and the distal podomere having five setae, of which the next to the innermost is the longest. Leg 5 in the male with the basal podomere lacking the inner expansion and bearing only the outer seta, and with the distal podomere having four terminal setae. Female genital field with a pair of plumose setae. Egg sac containing a single layer of eggs and carried with one narrow edge along the ventral abdominal surface. Abdomen (somites posterior to the genital) 4-segmented in both sexes.

Type species.—*Antillesia cardisomae*, n. sp. (The generic name alludes to the wide distribution of the genus in the Antilles, and the specific name to the crab host.)

Antillesia cardisomae, n. sp.

Type material.—More than 60 individuals representing both sexes, from the gill chambers of *Cardisoma guanhumi* Latreille collected in November 1955 on a mud flat at Port Henderson, St. Catherine, Jamaica, by Dr. Peter F. Bellinger. Holotype, allotype, and 28 paratypes (18 females and 10 males) deposited in the United

FIGS. 20–31.—*Antillesia cardisomae*, n. gen. and sp., female: 20, Rostrum, dorsal (B); 21, genital segment and abdomen, ventral (D); 22, caudal ramus, dorsal (A); 23, first antenna (C); 24, aesthetask on the first antenna (B); 25, second antenna (C); 26, labrum, ventral (B); 27, mandible (B); 28, oblique view of tip of the mandible (B); 29, first maxilla (B); 30, second maxilla (B); 31, maxilliped (B).



FIGS. 20–31.—(For legend see opposite page.)

States National Museum; the remaining paratypes in the author's collection.

Female.—Total length, not including setae, based on eight specimens, 1.051 mm (0.900–1.272 mm). Greatest width of thorax 0.130 mm (0.112–0.141 mm). Body (Figs. 18 and 19) colorless in alcohol. Rostrum (Fig. 20) minute, rounded, with two slender dorsal setae. Abdomen (Fig. 21) 4-segmented, with transverse rows of minute setae. Caudal ramus (Fig. 22) elongated, about 2.8 times longer than wide, bearing terminally a long inner seta (570μ) and a shorter, slightly curved, unilaterally pectinate outer seta (135μ), and four smaller setae as indicated in the figure.

First antenna (Fig. 23) 8-jointed, the aesthetask on the fourth podomere (Fig. 24) 40μ long and extending only to the middle of the seventh. Second antenna (Fig. 25) with a very short basal podomere, a long middle podomere incompletely divided on the mid-inner margin and bearing a single-jointed exopodite tipped with three setae, and a terminal podomere having four setae and a spine distally, numerous small spines along its inner edge, and a low protuberance covered with short hairs at the outer distal corner. Posterior margin of labrum (Fig. 26) slightly dentate medially and pectinate laterally. Mandible (Fig. 27) with a swollen base, a 2-jointed palp having four distal setae, and an elongate, indistinctly bipartite blade showing a prominent anterior protuberance and distally (Fig. 28) three ventral teeth, a dorsal seta, and numerous smaller teeth between. First maxilla (Fig. 29) with a broad inner lobe having two slender, curved setae on its anterior surface and distally two broad pectinate setae plus several smaller ones; with two slender outer lobes and an external seta. Second maxilla (Fig. 30) terminating in a clawlike spine and a pectinate seta; other parts as indicated in the figure. Maxilliped (Fig. 31) 2-jointed, the first podomere bearing a distal swollen plumose seta, the second bearing terminally a long curved pectinate claw with a minute seta near its base.

Rami of legs 1–4 3-jointed, except the 2-jointed endopodite of leg 1 (Fig. 32). Average measurements of leg 1, based on 10 specimens: length and width of the first podomere of the endopodite 98 × 18μ (96–103μ × 17–20μ), length of the inner seta 102μ (90–110μ), length of the second podomere 20μ (18–22μ), and length of the exopodite 68μ (64–70μ). Prominent groups of spines on the distal outer angles of the first and second exopodite podomeres of all four legs and of the second endopodite podomere of legs 2–4 (Figs. 33, 34, and 35). The spine and setal formula of legs 1–4 as follows:

	leg 1		leg 2	
	exp	end	exp	end
1st podomere	1:0	0:1	1:0	0:1
2d podomere	1:0	3	1:1	0:1
3d podomere	5		6	4

	leg 3		leg 4	
	exp	end	exp	end
1st podomere	1:0	0:1	1:0	0:1
2d podomere	1:1	0:1	1:1	0:1
3d podomere	6	5	6	5

Long inner seta on the second exopodite podomere of leg 1 absent.

Leg 5 (Fig. 36) with the inner expansion of the basal podomere having five terminal setae and in some specimens a row of small setae along the outer edge. A single outer seta on the basal podomere. Distal podomere with five terminal setae and a minute blunt peg about midway along the outer edge. The lengths of the setae (beginning with the outermost) as follows:

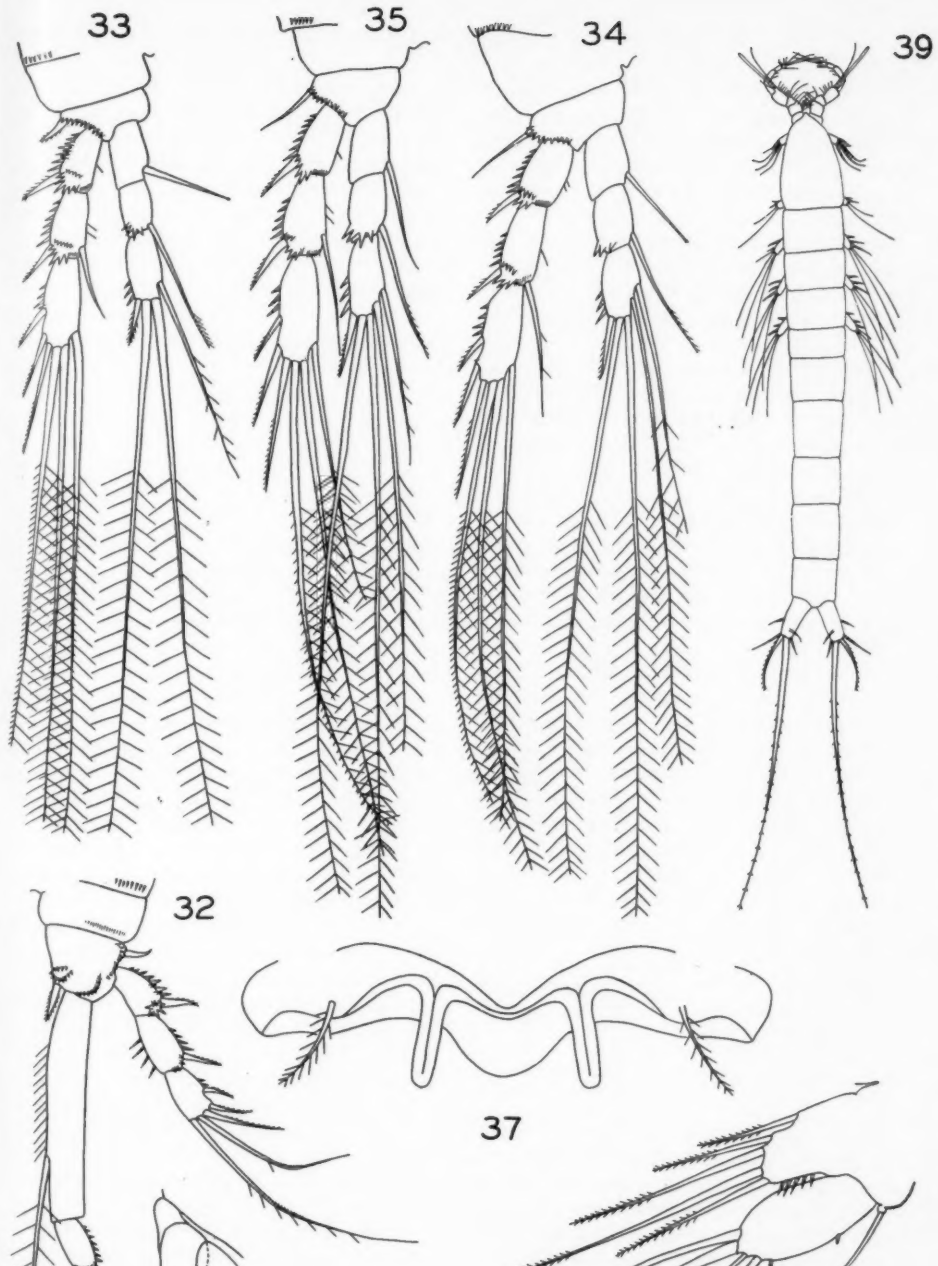
Distal Podomere				
13μ	54	59	116	77
11–17μ	45–58	56–64	102–128	68–81
Inner Expansion				
42	94	60	39	29
38–46	86–99	53–67	29–47	23–38

Genital field (Fig. 37) with a single plumose seta, directed posteriorly, on both sides.

Egg sac (Fig. 38) 386μ long, reaching to slightly beyond the middle of the third abdominal segment. Usually 8 eggs (5–9, based on 6 specimens) in a single layer. Flat plane of the egg sac oriented vertically to the abdomen, so that in ventral view of the entire female the egg sac appears to be a single row of eggs, only the edge of the sac being visible.

Male.—Body form as in Fig. 39. Total length, based on 10 specimens, 0.789 mm (0.700–0.943 mm). Greatest width of thorax 0.120 mm (0.112–0.125 mm). Abdomen (Fig. 40) 4-segmented,

Figs. 32–38.—*Antillesia cardisomae*, n. gen. and sp., female: 32, Leg 1 (A); 33, leg 2 (A); 34, leg 3 (A); 35, leg 4 (A); 36, leg 5 (C); 37, genital field (B); 38, egg sac (E).
Fig. 39.—Same, male: Dorsal (F).



FIGS. 32–39—(For legend see opposite page.)

with transverse rows of setae. First antenna (Fig. 41) 7-jointed and slightly prehensile, the fourth podomere bearing an aesthetask 90μ long, extending well beyond the tip of the antenna. Last podomere (Fig. 42) with a slender aesthetask.

Legs 1–4 like those of the female, with the same spine and setal formula, except for the endopodite of leg 3 (Fig. 43) which has the next to the outermost terminal seta much shorter than in the female.

Leg 5 (Fig. 44) with an outer pedicellate seta 49μ long on the basal podomere. Distal podomere 20 × 11μ with 4 terminal setae 12, 56, 61, and 30μ, respectively, beginning with the outermost. Spermatophore (Fig. 45) oval with a slender recurved neck.

Remaining parts like those of the female.

Oswald N. Morris has sent me specimens of *A. cardisomae* from *Cardisoma guanhumi* found on the banks of the Barnett River, near the Bogue Islands, Montego Bay, Jamaica, March 23, 1957.

John B. Lewis found this copepod in *C. guanhumi* at St. James, Barbados, in November 1955. These specimens differ only slightly from the Jamaican ones. The small setae along the outer edge of the inner expansion of the fifth leg are lacking. Since these setae are sometimes absent in Jamaican specimens, their presence or absence can not be regarded as a distinctive specific character. The lengths of the setae on leg 5 (based on nine specimens) are as follows (beginning with the outermost):

Distal Podomere				
14μ	48	54	113	83
13–14μ	46–53	49–59	90–121	67–98
Inner Expansion				
47	82	55	30	23
36–56	74–93	32–63	27–35	19–28

The average measurements of leg 1 of 10 females are: length and width of the first podomere of the endopodite 95 by 16μ (85–105μ × 14–18μ), length of the inner seta 92μ (86–105μ), length of the second podomere 21μ, and length of the exopodite 68μ (64–73μ).

I have examined specimens from *Cardisoma guanhumi* sent to Dr. Dorothy E. Bliss in 1955 from the Lerner Marine Laboratory at Bimini, Bahamas. In these the small setae along the outer margin of the inner expansion of leg 5 are absent. The lengths of the setae of legs 1 and 5 are somewhat different. The average measurements of leg 1 of 10 females are: length and width of the first podomere of the endopodite 84 × 15μ, length of the inner seta 82μ, length of the second podomere 18μ, and length of the exopodite 63μ. The setae of leg 5 are as follows (beginning with the outermost):

Distal Podomere				
13μ	37	50	104	64
11–15μ	33–43	43–59	96–115	56–75
Inner Expansion				
33	75	49	25	17
27–42	61–91	39–56	19–31	14–22

In nearly all cases the extreme ranges of these setae overlap those of the Jamaican specimens. It does not seem possible, therefore, to regard the Barbados and Bahama specimens as other than representing size variations within populations of the same species.

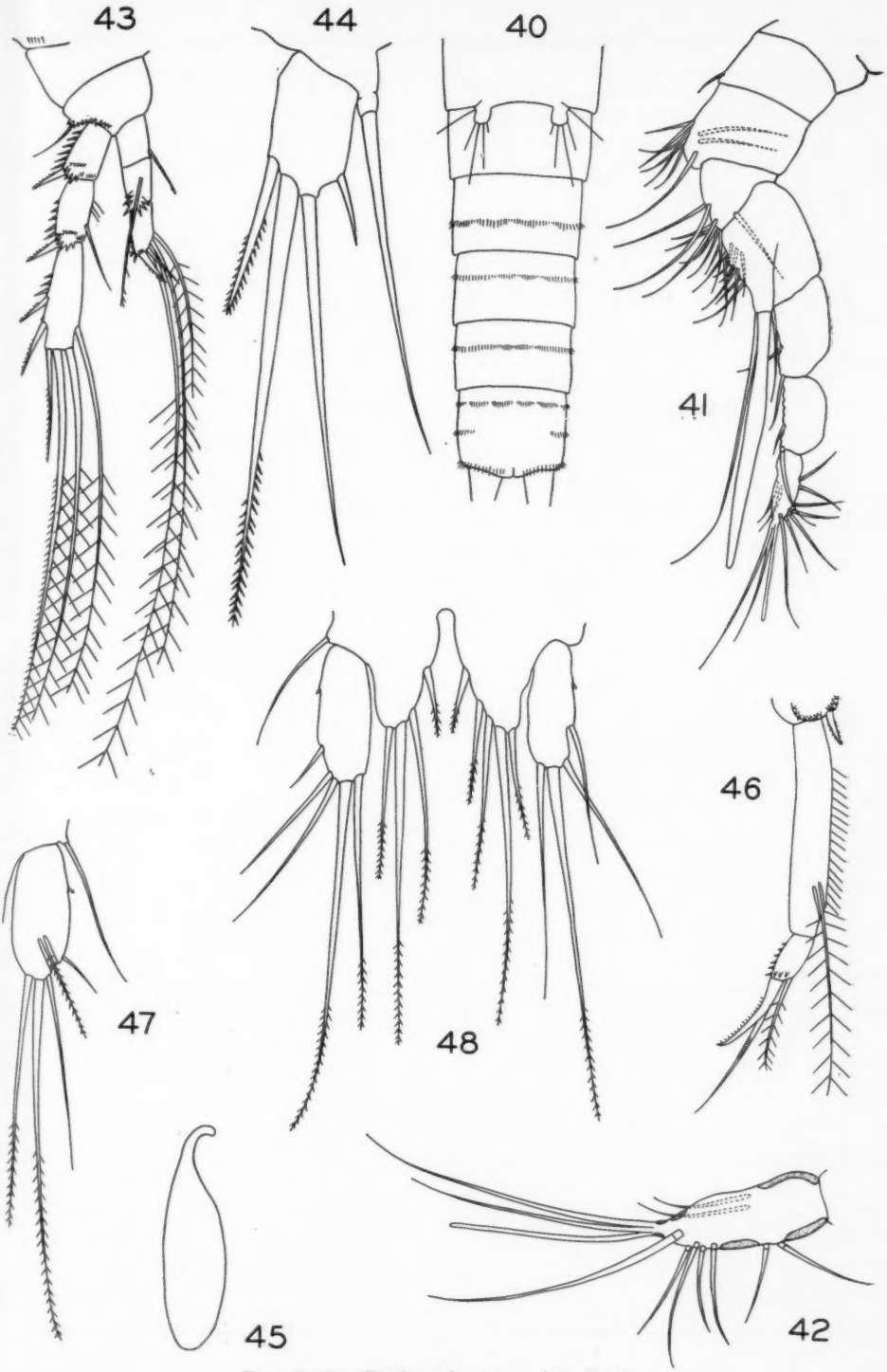
Considerable individual variation exists in this species. Not uncommonly the setae may be partially retracted (Figs. 46 and 47). Occasionally (in 5 out of 30 females dissected) one or more setae on leg 5 may be absent (Fig. 48), giving the leg an asymmetrical appearance. The setae on leg 5 in the same individual may vary markedly in length. In one specimen from Bimini, for example, the three innermost setae on the inner expansion measured 45, 19, and 14μ on one side and 36, 31, and 15μ on the opposite side. Great care should be exercised in interpreting the significance of setal variation in both number and length unless sufficient specimens are available for study. Description based on a single specimen may not always express the usual condition.

Although specimens of *Gecarcinus lateralis* from the same localities in the Barbados and the Bahamas were examined, no copepods were encountered, indicating a rather narrow host specificity.

Other specimens of *A. cardisomae* were recovered from washings of the gill chambers of *C. guanhumi* from Key West, Fla. (M.C.Z. no.

FIGS. 40–45.—*Antillesia cardisomae*, n. gen. and sp., male: 40, Genital segment and abdomen, ventral (D); 41, first antenna (C); 42, last podomere of first antenna (B); 43, leg 3 (A); 44, leg 5 (B); 45, spermatophore (C).

FIGS. 46–48.—Same, female: 46, Endopodite of leg 1 with partially retracted seta (A); 47, distal podomere of leg 5 with partially retracted seta (C); 48, abnormal leg 5 (C).



FIGS. 40–48.—(For legend see opposite page.)

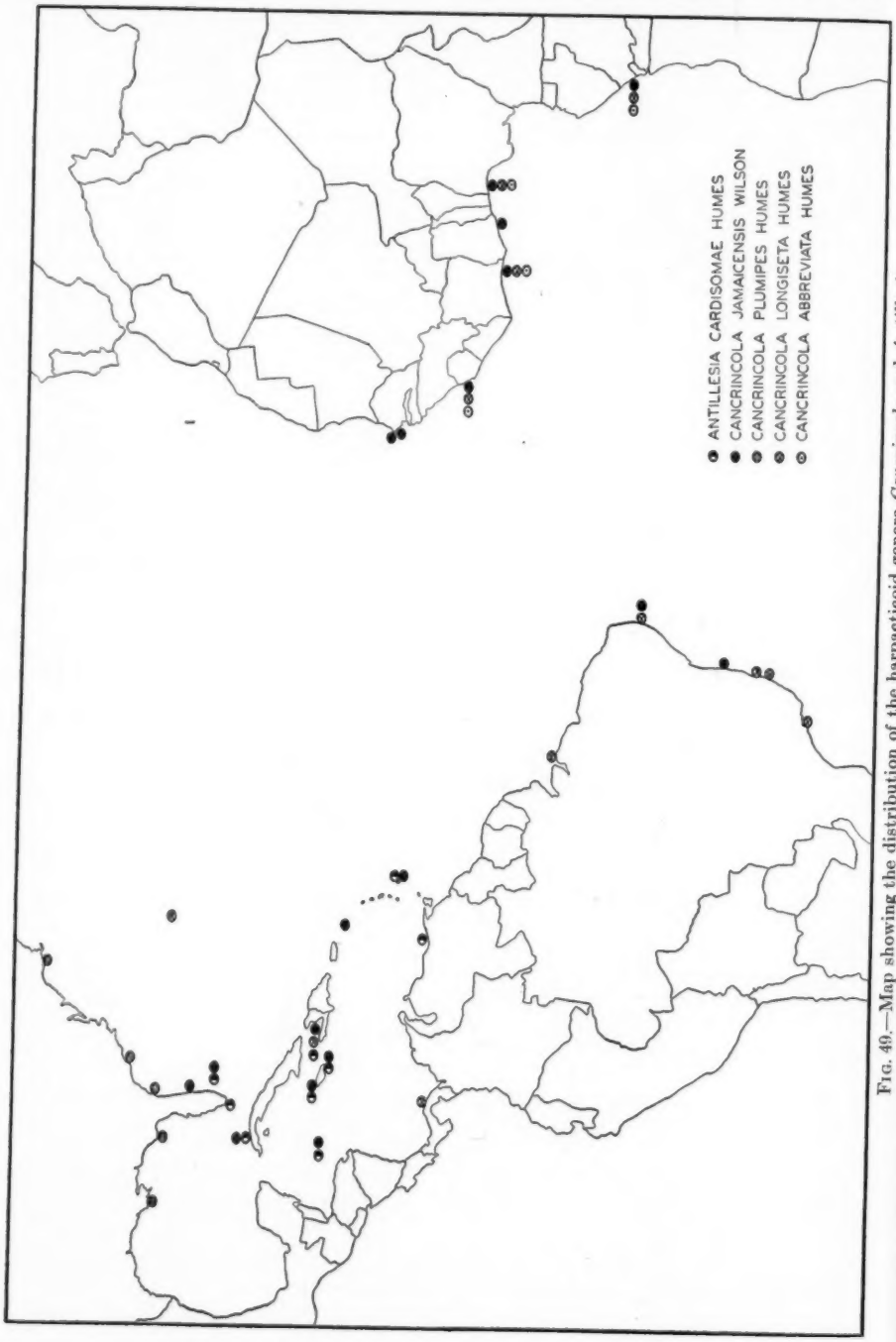


FIG. 49.—Map showing the distribution of the harpacticoid genera *Cancrincola* and *Antillesia*.

5600), Swan Island (no. 8659), Guanta, Venezuela (no. 9054), Grand Anse, Haiti (no. 5602), and Bahia Honda, Cuba (no. 5601). The known range of this copepod extends from the Bahamas through the West Indies to the Barbados, as indicated on the accompanying map.

The new harpacticoid genus *Antillesia* belongs to the Ameiridae, where it seems most closely related to the genus *Cancrincola* Wilson 1913. It differs from the latter, however, principally in having two terminal setae on the caudal ramus, in lacking a seta on the inner margin of the second exopodite podomere of leg 1 and in the spine and setal arrangement of legs 3 and 4, in the next to the innermost seta on the distal podomere of leg 5 in the female being the longest, in the orientation of the egg sac, in the slight sexual modification of the seta on the last endopodite podomere of leg 3 in the male, in the absence of a terminal hook on the male antenna, and in the structure of the fifth leg in the male.

SUMMARY

1. *Cancrincola jamaicensis* is redescribed in part and new collection records cited, extending its known range from Bimini, Bahamas, to Cannavieiras, Brazil.

2. *Cancrincola plumipes* is also partly redescribed and new collections from Florida, South Carolina, and Rhode Island recorded. *Sesarma cinereum* is reported as a new host.

3. *Cancrincola longiseta*, originally known only from West Africa, is reported for the first time in the New World, at several localities from the Bermudas to Rio de Janeiro.

4. A new harpacticoid genus and species, *Antillesia cardisomae*, is described from the gill chambers of *Cardisoma guanhumi* at several localities from the Bahamas to the Barbados.

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FIG. 49.—Map showing the distribution of the harpacticoid genera *Cancrincola* and *Antillesia*.

Education does not mean teaching people what they do not know. It means teaching them to behave as they do not behave.—JOHN RUSKIN.

ZOOLOGY.—*Appalachian Cambalidae: Taxonomy and distribution (Diplopoda: Spirostreptida)*. RICHARD L. HOFFMAN, Blacksburg, Va.

(Received September 23, 1957)

Although the American cambaloid millipeds, having been the subject of a careful treatise by H. F. Loomis in 1938, are in a more satisfactory taxonomic condition than most other groups of diplopods in this country, the examination of recently acquired material indicates a need for some nomenclatorial adjustments in the genus *Cambala*. Ideally such changes should be made in the body of a complete generic revision. Material is now being accumulated for a detailed study of *Cambala*, but the present scarcity of specimens of the very poorly known Ozarkian and Midwestern species will postpone its completion for an indefinite period of time. For this reason, it seems worthwhile to clear up the confusion of the large eastern species promptly, before additional synonymy accumulates in the literature.

The problem is one that can be settled on the basis of geographic distribution, and the present resolution of it is due in large measure to the interest and diligence of my friend Leslie Hubricht, collector of most of the existing material. The following treatment is based on 68 collections totaling well over 300 individual specimens of *Cambala*.

Prior to 1938 only two species of *Cambala* had been named: *annulata* (Say 1821), of the Atlantic coast region, and *minor* (Bollman, 1888), of the Interior Lowlands. In his monograph of the American cambaloids, Loomis showed, however, that in fact two well-marked species—easily recognizable by several structural characters apart from the male gonopods—occurred in the southeast within the range previously ascribed only to *annulata*.

Making what, on the basis of his limited material, was certainly a justifiable decision, Loomis restricted the name *annulata* to the population in which the peritremata are larger and more distinctly "pyriform" as stipulated in Say's original description. Of this species, Loomis had material from the mountains of eastern Tennessee and western North Carolina. For the other form—the *annulata* of earlier workers—he proposed the new name *Cambala cristula*, an arrangement which has been accepted by all workers who have subsequently dealt with the group.

It is now apparent, however, on the basis of much subsequent field work, that the name *cristula* is based upon the common and widespread member of the genus, which ranges over much of eastern United States and which is apparently the only cambaloid occurring in the Atlantic Coastal Plain. On the other hand, the species which Loomis identified as *annulata* seems clearly to be confined to a narrow strip of high country making up the Iron and Unaka Mountain ranges of the southern Appalachians. Inasmuch as Say's excursion to Florida in 1818, during which the types of *annulata* were taken, was limited to the coastal area, it seems reasonable to assume that he would have collected the cambaloid known to occur there rather than a species of restricted range which is endemic to a region he never visited. The qualifying adjective "pyriform" used by Say in his description could equally well be applied to either of the species, although of course the peritremata of the montane species are much more accentuated and "pear-shaped."

This identification of the name *annulata* on the basis of geographical evidence occasions a certain amount of departure from existing nomenclature. For the present, the name *cristula* Loomis 1938 (type locality, Etowah, Tenn.) will have to be regarded a junior synonym of *annulata* Say 1821, with the reservation that it will be available should the trans-Appalachian segment of the *annulata* population be found subspecifically distinct from the typical form of the southern Atlantic Coastal Plain. The species which Loomis treated as *annulata* must now be provided with a new name.

For the present, with extended descriptions available in Loomis's valuable paper, it does not seem necessary to go into detail regarding comparative morphology, a matter which will be covered thoroughly in the

forthcoming generic revision. Only the salient diagnostic characters of the two Appalachian species are cited, and these two are readily separated from all other species by their large size as well as by details of the male genitalia. The two species under consideration may be distinguished from each other by numerous structural differences, of which some of the most conspicuous have been selected for the diagnostic comparison which follows.

It seems appropriate that the montane *Cambala* be named in honor of Mr. Hubricht, who although primarily concerned with the study of terrestrial gastropods has nonetheless secured more cambalids than have all other collectors combined, and it is largely through his efforts that the present treatment was possible.

1. Body very long and slender, 18 to 20 times as long as wide, and distinctly narrowed toward the anterior end; peritremata very pronounced, subconical in shape, and on fourth segment much larger than the dorsal crests; coxal plates of anterior gonopods distally acuminate and not concealed by the telopodites; coxal process of posterior gonopods long, slender, and simple, directed distad..... *Cambala hubrichti*, n. sp.

   Body distinctly stouter, 14 to 15 times as long as broad, the anterior segments not conspicuously narrowed; peritremata lower and more rounded, those of fourth segment not larger than the dorsal crests; coxal plates of anterior gonopods distally furcate and concealed by the incurved telopodites; coxal process of posterior gonopods short and stout, distally with several marginal dentations..... *Cambala annulata* (Say)

Cambala annulata (Say)

Julus annulatus Say, 1821, Journ. Acad. Nat. Sci. Philadelphia, **2:** 103.

Cambala lactarius Gray, 1832, *in* Griffith: "The Animal Kingdom, arranged in accordance with its organization by the Baron Cuvier . . . etc." **14:** pl. 135, fig. 2; **15:** 784 (misidentification of this species as *Julus lactarius* Say?).

Spirobolus annulatus Wood, 1865, Trans. Amer. Philos. Soc., n.s., **13:** 212.

Cambala annulata Cope, 1869, Proc. Amer. Philos. Soc. **11:** 181.—Bollman, 1887, Ann. New York Acad. Sci. **4:** 42; 1888, Proc. U. S. Nat. Mus. **11:** 339.—Chamberlin, 1918, Psyche **25:** 24.—Brimley, 1938, Insects of North Carolina: 498.—Chamberlin, 1947, Proc. Acad. Nat. Sci. Philadelphia **99:** 58.

Cambala cristula Loomis, 1938, Proc. U. S. Nat. Mus. **86:** 39, fig. 12; 1939, Bull. Mus. Comp. Zool. **86:** 168; 1943, Bull. Mus. Comp. Zool. **92:** 390.—Causey, 1952, Amer. Midl. Nat. **50:** 156.

Type specimen.—Female, in the British Museum (Natural History), presented by Thomas Say.

Type locality.—"Southern States" (Say), probably the coastal region between Charleston, S. C., and Jacksonville, Fla.

Distribution.—The range of this species, as known at present, is fairly extensive, extending from central Virginia south to northern Florida, west to Alabama, and north to the unglaciated parts of Ohio and Indiana.

Most of the localities plotted on the accompanying map are based on specimens in my collection. For records in the Coastal Plain, however, we must turn to the literature. In the original description of *Cambala cristula*, Loomis recorded specimens from Adams Run, Charleston County, South Carolina, and these millipeds are probably representative of the local population from which Say obtained his type specimen. Subsequently (1943) Loomis reported the species from Florida Caverns, north of Marianna, Jackson County, Fla., and from Kymulga Cave, 7 miles northwest of Childersburg, Talladega County, Ala., both collections being made by Leslie Hubricht. Other records of *annulata* from more western states, such as those of Bollman (1888) for Arkansas, and Chamberlin (1918) for Louisiana, are based upon other species of the genus, which have been subsequently described as new. Early records for Indiana by Bollman (1889) are based upon specimens of *Cambala minor*, but recent collections of *annulata* from Jefferson County, Indiana (Hubricht) and from Hocking County, Ohio (Bailey, Thomas, and Walker) establish that species north of the Ohio River in unglaciated territory.

Normally *annulata* is somewhat secretive in habits, occurring at the deepest levels of humus deposits or in the burrows of small mammals, and this fact has doubtless been responsible for the idea that the species is scarce. In the Appalachian region of southwest Virginia and western North Carolina, one can usually find *annulata* in abundance. For instance, in the vicinity of Blacksburg, Va., it is one of the most frequently encountered diplopods, and large collections attest to its prevalence in the western Piedmont area of North Carolina. Further to the north, however, the species becomes very scarce, for at Charlottesville Va., only two specimens could be found in nearly four years of local field work, and around Clifton Forge, in western Virginia, only

one has been collected in more than a decade of search. No material has been seen in extensive collections of millipeds made around Washington, D. C., and it seems possible that *annulata* does not extend farther north along the east coast than is now known.

Altitudinally, *annulata* ranges from sea level up to around 4000 feet at Highlands, N. C., and Burkes Garden, Va. There appear to be no structural variations associated from the material from high elevations.

According to my field experience and Mr. Hubricht's collection data, *annulata* is most frequently found in rather dry upland oak woods, usually deep in humus but occasionally under partly buried logs and rotting stumps in dry lo-

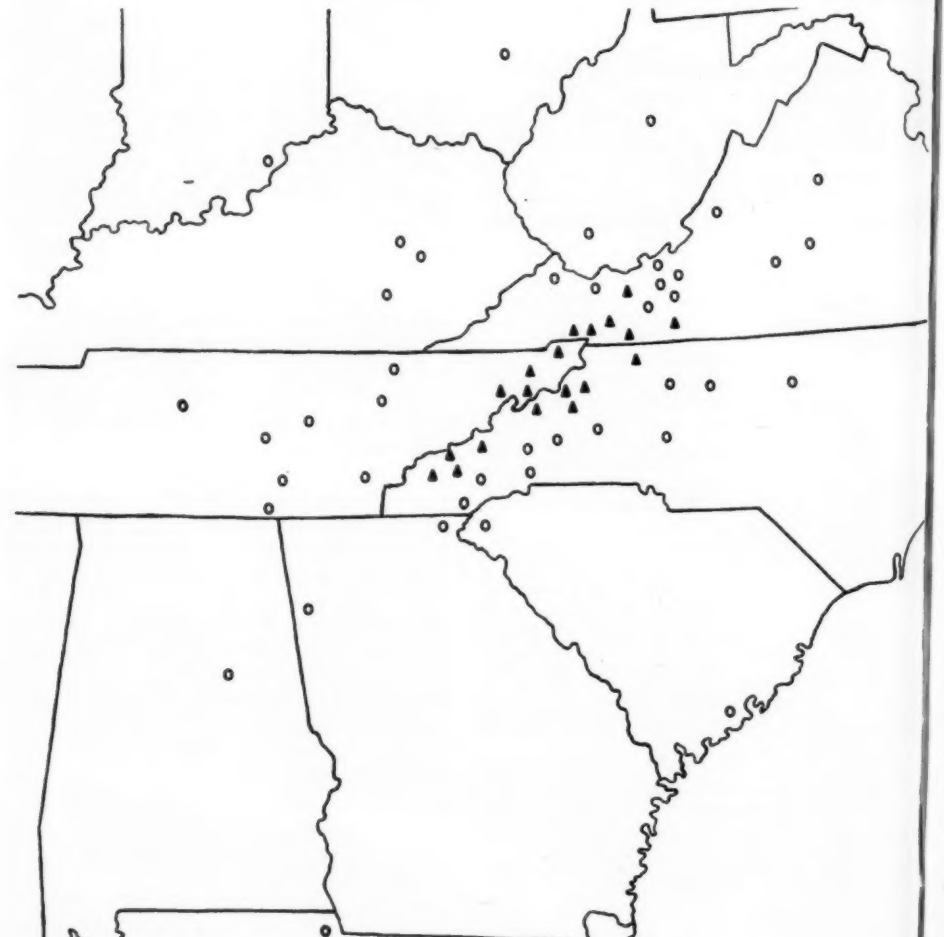

FIG. 1.—Southeastern United States, showing the distribution of *Cambala annulata* (Say) by open circles and of *Cambala hubrichti*, n. sp., by solid triangles. Records are based upon specimens personally examined and literature reports considered to be reliable.

cations. The species is gregarious, and usually several can be found together. Curiously enough, I have never discovered one in motion, even at night when nearly all other millipeds are active. When handled, specimens exhibit a peculiar slowness and stiffness of motion, and tend to curl into a loose spiral. Mated pairs have been found in May and June. The observed season of activity ranges from mid-February to November at Blacksburg, Va.

Cambala hubrichti, n. sp.

Cambala annulata (nec Say, 1821) Loomis, 1938, Proc. U. S. Nat. Mus. **86:** 37, fig. 11.—Chamberlin, 1952, Great Basin Nat. **12:**30.—Chamberlin and Hoffman, 1958, U. S. Nat. Mus. Bull. 212 (in press).

Type specimens.—Male holotype, U. S. Nat. Mus. (no. 2463), from a bluff along the Doe River, 1 mile northwest of Hampton, Carter County, Tenn., collected by Leslie Hubricht on May 3, 1951. Topo-paratypes from the same collection are deposited in the Zoologisch Museum, Amsterdam, and the Senckenberg Museum, Frankfurt a/M.

Diagnosis.—A very large species of *Cambala*, adults usually more than 50 mm in length, with a very strongly sculptured body about 18 to 20 times as long as its greatest diameter. From *C. annulata*, the only other species of equal size, this species is readily distinguished by the characters set forth in the preceding key couplet. In no other form of the genus are the peritremata of the 4th segment larger than the intervening dorsal crests.

This form has been adequately described and illustrated in the work of Loomis cited above, under the name *annulata*. Detailed consideration of the male genitalia is reserved for a future treatment.

Distribution.—*Cambala hubrichti* occurs over a narrow strip of mountainous terrain in the adjoining parts of southwest Virginia, eastern Tennessee, and western North Carolina. To the south, it has been taken as far as the Nantahala Gorge in Swain County, North Carolina; northward, to the Alleghenies in Wythe County, Virginia. The species is not, however, limited to high elevations, having been taken as low as 1,500 feet at several localities.

Specimens have been collected in the Balsams, the Iron Mountains, the Unacoi range, Holston Mountain, satellites of the Great Smokies, and on the Blue Ridge itself northeast of Asheville. There are still no records, however, for the Black Mountains, although the species surely occurs there. All of the foregoing mountains and ranges are, physiographically, part of the Southern Section of the Blue Ridge Province.

Perhaps the most interesting locality for *hubrichti* is its northernmost, on Walker Mountain, a long and prominent mountain on the northwest side of the Tennessee River Valley and a component of the Ridge and Valley physiographic province. That a milliped species basically endemic to the southern Blue Ridge should occur more or less physiographically isolated at the northern extremity of its known range is of considerable zoogeographic interest. This instance reflects a distributional pattern recently established for the salamander *Plethodon jordani metcalfi* Brimley, as well as for species in other animal groups.

The evidence from both present-day physiography and known animal distribution indicates a former faunistic continuity from the Appalachian Plateau region of central West Virginia south and eastward to the parallel but offset mountains of the Southern Blue Ridge. The main trend of the former high country was clearly south across the region now included in southwest Virginia, and even today that region remains studded with isolated high peaks and ridges along the divide between the upper Tennessee and Kanawha river drainage systems.

Although the ranges of *annulata* and *hubrichti* overlap both horizontally and altitudinally at several areas, the species have not yet been taken together or in close proximity. Despite this apparent vicariation (which some systematists take, *per se*, to indicate subspecific relationship), the structural differences between these two large cambalids are so numerous as to leave no doubt that they are worthy of full specific rank. In the material examined thus far, I have seen no specimens which could be considered intermediate in any respect.

Records upon which the present concept of the species' range is based are listed as follows, the collections being made by me except as otherwise credited.

VIRGINIA. Wythe County: Big Bend Recreation Area, 4,000 feet, Big Walker Mountain about 10 miles northwest of Wytheville, August 6, 1956. Smyth County: Brushy Mountain, 5 miles east of

Marion, May 4 and August 20, 1954. Patrick County: Pinnacles of Dan, 6 miles southwest of Vesta, May 8, 1951 (W. B. Newman and R. L. Hoffman), also May 7, 1955 (W. T. Keeton, W. C. Lund, and R. L. Hoffman), also April 20, 1957 (R. E. Crabill, Jr., and R. L. Hoffman). Grayson County: Helton Creek, east side of Mount Rogers, 4,000 feet, June 19, 1950, and Peach Bottom Creek, 4 miles southwest of Independence, June 20, 1950 (J. A. Fowler and Hoffman); Comer's Rock Recreation Area, 2 miles northwest of Comer's Rock, June 15, 1950 (Leslie Hubricht). Washington County: Laurel Creek near Damascus, April 28, 1951 (Hubricht).

TENNESSEE. Johnson County: Holston Mountain, 2 miles west of Shady Valley, June 20, 1950 (Fowler and Hoffman). Carter County: Doe River bluff, 1 mile northwest of Hampton, May 3, 1951 (Hubricht). Unicoi County: Unaka Springs, southeast of Erwin, September 23, 1951, also June 2, 1952. Green County: Camp Creek, June 1947 (Mike Wright).

NORTH CAROLINA. Alleghany County: Air Bellows Gap, June 20, 1955 (Arnold VanPelt). Watauga County: 6 miles north of Boone, June 17, 1948 (Wright). Avery County: Route 221, east side of Grandfather Mountain, June 1, 1954; between Newland and Elk Park, May 20, 1956 (Keeton, Lund, and Hoffman). Mitchell County: 3 miles northwest of Spruce Pine, June 4, 1954. Yancey County: Route 19, 2 miles east of the State line, June 2, 1952. Jackson County: Soco Falls, 10 miles northeast of Cherokee, May 20, 1956 (Keeton, Lund, and Hoffman). Swain County: Nantahala Gorge, 8 miles southwest of Bryson City, May 6, 1951 (Hubricht).

In addition to the foregoing localities, the species has been reported by Chamberlin (1952) from Asheville, Buncombe County, N. C. The early record of Bollman (1888) for Balsam, Jackson County, N. C., is probably based upon specimens of *hubrichti*, but his specimens cannot at present be found for a verifying study. The material described by Loomis in 1938 was collected by O. F. Cook between Elizabethton and Roan Mountain, Tenn., probably within a few miles of the locality here selected as typical of this species.

ON THE ORDINAL POSITION OF THE CAMBALIDAE

The present allocation of the family Cambalidae to the Spirostreptida is at variance with the classification used in the forthcoming "Checklist of the Millipeds of North America" and requires some qualification. On the basis of recent studies of the comparative morphology in the cambaloid-spirostreptoid group of millipeds, I have found no basis for the recognition of the cambaloids as a separate order. Numerous annectant groups (such as the Choctelli dae, Epinannolenidae, Physiostreptidae, and even Old World Cambalidae) constitute a network of intermediate conditions both in gonopod structure as well as configuration of the mouthparts. Some of this evidence is included in a report on the family Choctellidae, now in preparation, in which the order Spirostreptida is divided into three subsuborders: Cambalidea, Epinannolenidea, and Spirostreptidea.

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HERPETOLOGY.—*Contributions to the herpetology of Maryland and Delmarva, 13: Piedmont herpetofauna on coastal Delmarva.* CLYDE F. REED, Reed Herpetorium, Baltimore, Md. (Communicated by Doris M. Cochran.)

(Received September 13, 1957)

The Delmarva Peninsula, which extends from the Pennsylvania border adjacent to Maryland and Delaware on the north, the Susquehanna River and Chesapeake Bay on the west, the Delaware River and Atlantic Ocean on the east, to Cape Charles, Va., and the mouth of the Chesapeake Bay on the south, is made up predominantly of coastal soils. In northern Cecil and New Castle Counties the geological Fall Line passes, dividing the Piedmont from the Coastal Provinces. All land south of the Fall Line is considered as coastal in origin, being composed of sands and alluvial soils. There are no extensive solid rocks or stones in this area.

In eastern United States the Fall Line extends from Georgia northward across the Carolinas and Virginia, passing through the center of Washington, D. C., Baltimore, Wilmington, Philadelphia, across central New Jersey, Long Island, and thence to Cape Cod, Mass. Up to the Potomac River and the Chesapeake Bay, most of the southern Coastal Plain is continuous, being divided here and there by either fresh-water rivers more inland or tidal and low level rivers along the Atlantic coast. The Delmarva Peninsula is definitely isolated by the Chesapeake Bay from this southern Coastal Plain. Southern Maryland is also separated from either of these areas either by the Potomac River from the south or by the Chesapeake Bay to the east. Likewise, southern New Jersey is isolated from the Delmarva Peninsula by the Atlantic Ocean and the Delaware River to the west and south and by other areas of the Atlantic Ocean from Long Island and southern New England.

Most of the large rivers of the southern Coastal Plain have their beginnings in or above the Piedmont region; therefore, it would not be inconceivable to expect to find some Piedmont species of both plants and animals on the Coastal Plain adjacent to these rivers. In our area the Potomac River flows from the mountain regions west of the southern Maryland Coastal Plain. At the present time the Potomac flows into the Chesapeake Bay about midway up the western side of the bay. However, it is saline and tidal for about 70 miles, up to Washington, D.C.; above that point it is Piedmont, with fresh water, and rocky. The rivers on the western side of southern Maryland which flow into the Potomac River have their origins in the coastal areas of this region, as Mattawoman, Nanjemoy, Wicomico, St. Marys, and Anacostia Rivers. In contrast to these rivers, those on the eastern side of southern Maryland have their origins in the Piedmont region and flow on to the Inner Coastal Plain, as the Little and Big Gunpowder Falls, Patapsco, and Patuxent Rivers; there are some rivers in between these along the Chesapeake Bay which originate on the Coastal Plain and flow directly into the Chesapeake Bay, as Bush, Back, South, West, Severn, and Magothy Rivers.

Two major rivers which have their origins and over 98 percent of their drainage in Piedmont areas flank the Delmarva Peninsula; they are the Susquehanna and the Delaware. The land masses to either side of the Susquehanna River are Piedmont nearly to the mouth of the river at Havre de Grace (Harford County) and Perryville (Cecil County), both of these cities being at the very mouth of this river at the Chesapeake Bay. The Delaware River ceases to be Piedmont north of Philadelphia and becomes quite wide and saline as it approaches Wilmington. It develops into the Delaware Bay separating Delaware from New Jersey.

There are several small rivers and creeks in the northern portion of the Delmarva Peninsula which have their origins on Piedmont soils. Some of them enter the Susquehanna River above the Fall Line, as

Octoraro and Conowingo Creeks in Cecil County. Others flow down from Pennsylvania off the Piedmont on to Coastal regions in Cecil and New Castle Counties, as Little and Big Elk Creeks which form Elk River and the Northeast River; these rivers enter the Chesapeake Bay directly. The Brandywine Creek enters the Delaware River. Between Elk River and Northeast River is a peninsula known as Elk Neck, upon which many species of plants and animals known to be otherwise Piedmont in distribution abound. One would expect to find Piedmont species in this area for several reasons: (1) Rivers with Piedmont origins flow along either side of the peninsula; (2) the land mass is contiguous with the Piedmont soils and areas to the north; (3) this is the end of the land mass, and many species migrating southward find natural barriers on all sides, mainly water; for many it is their most southern distribution on the Delmarva Peninsula.

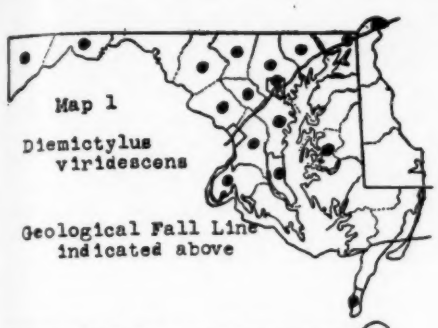
Except for these few small rivers and creeks in the northern portion of the Peninsula, all the rest of the rivers on the Delmarva Peninsula have their origins within the land mass of the Peninsula. An interesting observation concerning the rivers on the Delmarva Peninsula is that there are very few rivers or creeks of any size on the eastern side, as Appoquinimink and Blackbird Creeks, Smyrna River, Leipsic River, Mispillion Creek, Cedar Creek, Broadkill Creek, and Indian River. None of these creeks or rivers are over 25 miles long, and they all originate in Delaware. On the western side there are many very long rivers, some over 50 miles long, traversing both Delaware and Maryland and emptying into the Chesapeake Bay, as Bohemia, Sassafras, Chester, Choptank, Transquaking, Nanticoke, Wicomico (not the Wicomico River of southern Maryland), and the Pocomoke Rivers. The fresh-water areas from Pocomoke City south to Cape Charles consist mainly of millponds, creeks and drainage ditches. There are very few areas with fresh water drainages of any size, and these soon become saline and marshy before reaching either the Chesapeake Bay or the Atlantic Ocean.

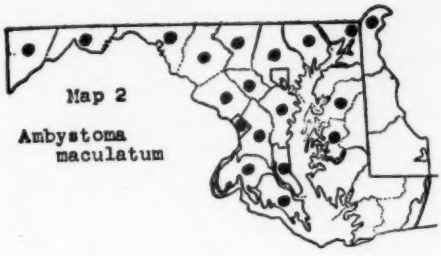
The entire area of the Delmarva Peninsula south of the Chesapeake and Delaware Canal, which empties into the Elk River, is Coastal Plain and the land masses east of it (southern New Jersey) and west of it (Maryland, from Havre de Grace to St. Marys City, and Virginia, from the Potomac River to Norfolk) are Coastal Plain, the former being known as Outer Coastal Plain and the latter, as Inner Coastal Plain. On this Coastal Plain there are many areas which possess considerable numbers of Piedmont plants and Piedmont animals. The presence of the animals is much easier to explain than is the presence of the plants.

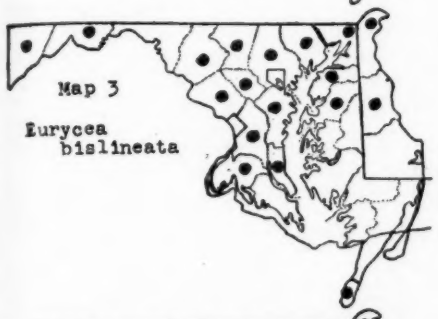
This paper deals with those species of the herpetofauna that are predominantly Piedmont in distribution in Maryland and the Delmarva Peninsula but that are also known from the Coastal Plain of southern Maryland and the Delmarva Peninsula. Only the counties on Delmarva in which specimens are definitely known to have been collected and are available are listed below. The annotated lists of these species appear in the *Contributions to the Herpetology of Maryland and Delmarva*, no. 6 through no. 11, published by the author; additional records may be found in other *Contributions* (see no. 5 for bibliography).

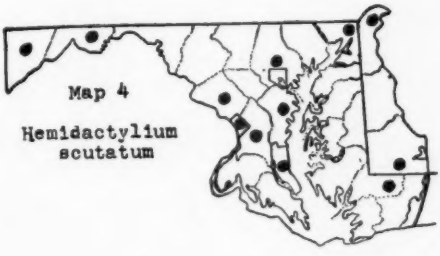
There are 17 species of herptiles usually considered as being upland or Piedmont which are found on coastal Southern Maryland and on Delmarva. It is interesting to note at this point that many plants also reach their southern limit in this area. These are annotated in another paper dealing with northern Piedmont species of plants which reach their southern limit on Delmarva, or in southern Maryland. Some of these species of plants reach as far south as Accomac County in Delmarva Virginia. There is a Piedmont forest along the Atlantic Ocean from Stockton (Worcester County), Maryland, to Atlantic (Accomac County), Virginia, about 30 miles long and about 10 miles wide. The author has collected about 150 species of Piedmont plants in this area in the last five years. This flora which centers around the town of Silva, Virginia is annotated in a botanical paper; the ferns of which have been published in Amer. Fern Journ. **46:** 148–151. 1956.

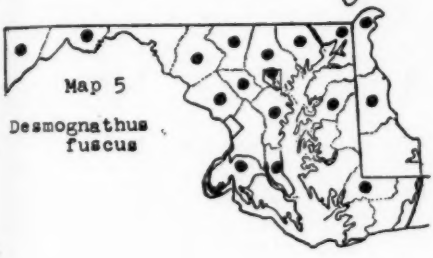
The maps accompanying this article show

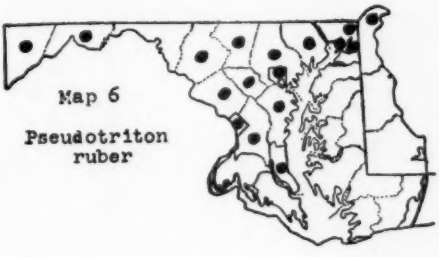


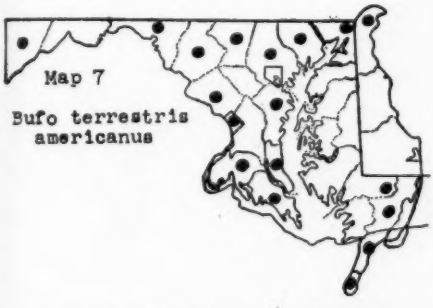


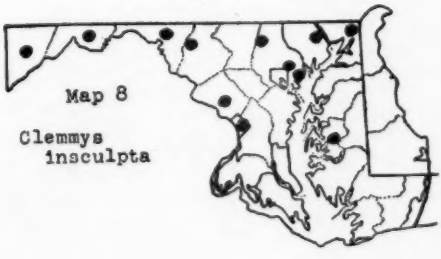












the county distribution in Maryland and Delmarva; the geological Fall Line is indicated and the counties on Delmarva below it are mentioned where Piedmont species of herptiles have been collected.

1. *Diemictylus viridescens viridescens* Rafinesque. New Castle (Newark, Piedmont); Cecil (Octoraro Creek Valley, Piedmont); Talbot (Seth Demonstration Forest); Northampton (Cape Charles). Map 1.

2. *Ambystmoa maculata* (Shaw). New Castle

Map 9
Natrix
septemvittata
Map 10
Storeria
occipitomacu-
lata
Map 11
Haldea
valeriae
Map 12
Carphophis
amoenus
Map 13
Lampropeltis
getulus
Map 14
Lampropeltis
doliata
triangulum
Map 15
Opheodrys
vernalis
Map 16
Diadophis
punctatus
edwardsi
Map 17
Rana
sylvatica

(Wilmington); Cecil (along Susquehanna River from Conowingo to Port Deposit and Elk Neck); Queen Annes (Stine, 1953); Talbot (Stine, 1953). Map 2.

3. *Eurycea bislineata bislineata* (Green). New Castle (Hollyoak near Wilmington); Cecil (Conowingo to Port Deposit); Queen Annes (Centerville); Kent, Md. (near Sassafras River); Kent, Del. (Brown's Branch); Northampton (Eastville). Map 3.

4. *Hemidactylium scutatum* (Schlegel). New Castle (Newark, Piedmont); Cecil (Conowingo to Port Deposit); Sussex (Millsboro); Wicomico (Quantico). Map 4.

5. *Desmognathus fuscus fuscus* (Rafinesque). New Castle (Shellpot Run near Wilmington; Bradywine Creek); Kent, Del. (Brown's Branch); Cecil (Conowingo to Port Deposit; Bainbridge; Pusey Creek; Dove Run); Queen Annes (Centerville); Wicomico (Conant, 1945). Map 5.

6. *Pseudotriton ruber ruber* (Sonnini). Cecil (Elk Neck; Big Bohemia Creek); New Castle (Wilmington; Newark). Map 6.

7. *Bufo terrestris americanus* Holbrook. New Castle (Conant, 1945); Cecil (Elk Neck: along Susquehanna near Octoraro Creek); Kent, Md. (Massey); Wicomico (Conant, 1945); Worcester (Conant, 1945); Accomac (Conant, 1945); Northampton (Hog Island). Map 7.

8. *Clemmys insculpta* (LeConte). Cecil (along Susquehanna below Conowingo); Talbot (Easton). Map 8.

9. *Natrix septemvittata* (Say). New Castle (Newark and Wilmington); Cecil (Elk Neck; Camp Horseshoe; Octoraro Creek; Rodney Scout Camps); Kent, Md. (Chestertown). Map 9.

10. *Storeria o. occipitomaculata* (Storer). Cecil (Elk Neck; Rodney Scout Camps); Queen Annes (Centerville); Dorchester (Blackwater Refuge); Worcester (Pocomoke State Forest; Old Furnace near Snow Hill). Map 10.

11. *Haldea v. valeriae* (Baird and Girard). Cecil (Elk Neck; Rodney Scout Camps; Rising Sun); Kent, Md. (TYPE locality); Wicomico (Quantico); Worcester (Stockton; Old Furnace near Snow Hill; Corbin); Accomac (Silva); Northampton (Hog Island; Cobbs Island). Map 11.

12. *Carphophis a. amoenus* (Say). Cecil (Elk Neck; Rodney Scout Camps); Queen Annes (Carmichael; Centerville; Ruthsburg); Kent, Md. (Conant, 1945); Sussex (Conant, 1945); Wicomico (Conant, 1945); Worcester (Berlin; Pocomoke State Forest); Accomac (Wattsville). Map 12.

13. *Lampropeltis g. getulus* (Linnaeus). Cecil (Port Deposit; Northeast; Elk Neck; Rodney Scout Camps); Kent, Md. (Kennedyville); Queen Annes (Centreville; Crumpton; Queenstown; Ruthsburg); Talbot (Easton); Sussex (Ocean View); Dorchester (Blackwater Refuge; Gum Swamp; Cambridge); Wicomico (Powellville; Quantico; Salisbury; Willards); Worcester (Bishopville; Berlin; Pocomoke River near Snow Hill); Somerset (Westover; Waterloo Farm on Monie Creek); Accomac (Conant, 1945); Northampton (Cape Charles). May 13.

14. *Lampropeltis doliata triangulum* (Lacépède). New Castle (north of Fall Line, Conant, 1945); Cecil (Camp Horseshoe; Conowingo; Rising Sun; Stony Run; Elk Neck). Map 14.

15. *Opheodrys vernalis vernalis* (Harlan). Cecil (Conowingo). Map 15.

16. *Diadophis punctatus edwardsi* (Merrem). New Castle (Wilmington); Cecil (Elk Neck; Gray's Hill; Elkton; Rodney Scout Camps). Map 16.

17. *Rana sylvatica sylvatica* LeConte. New Castle (Townsend); Cecil (Susquehanna River from Conowingo to Port Deposit); Kent, Del. (Brown's Branch); Kent, Md. (Mansueti, 1940); Queen Annes (Mansueti, 1940); Dorchester (Mansueti, 1940); Wicomico (Powellville; Quantico); Worcester (Pocomoke State Forest; Snow Hill). Map 17.

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ICHTHYOLOGY.—*Two new species of* Anampses *from the Hawaiian Islands, with notes on other labrid fishes of this genus.*[1]

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More species of the family Labridae (wrasses) are known from the Hawaiian Islands than any other family of reef fishes. This preponderance is furthered in the present paper by the description of two more, both species of *Anampses* Quoy and Gaimard. A key to the four Hawaiian species of this genus and discussion of related forms from other regions of the tropical Indo-Pacific are also presented.

I wish to express my gratitude to Dr. William A. Gosline, of the University of Hawaii, for kindly providing the single paratypes of the two new species, with the prior knowledge that they probably represent undescribed forms, and to Dr. James E. Böhlke, of the Academy of Natural Sciences of Philadelphia, and Robert H. Kanazawa, of the United States National Museum, for pertinent information.

The holotypes of the two new species are in the United States National Museum (U.S.N.M.).

The genus *Anampses* is characterized as follows: Mouth small; lips moderately fleshy; a single pair of large, protruding, incisiform teeth anteriorly in the upper jaw and a similar, more medial pair in the lower jaw (the upper incisors are slightly longer and broader and the edges sharper than the lower incisors; the uppers project outward at an angle of about 45°, the lowers directly forward or slightly downward); remaining teeth minute, generally imperceptible; body compressed, moderately deep (the depth contained about 2.5 to 4.0 times in standard length); head scaleless; body with moderately large scales (subgenus *Pseudanampses*[2] excepted) except for region of nape and thorax where the scales are small; 27 to 29 scales in lateral line (49 to 51 in *Anampses* (*Pseudanampses*) *geographicus*); lateral line continuous, angling down sharply at the level of about the ninth dorsal soft ray; gill membranes attached to isthmus; preopercle entire; dorsal fin rays IX, 12 (rarely 11 or 13); anal fin rays III, 12 (rarely 11 or 13); pectoral fin rays 13 (the uppermost a bony splint); caudal fin truncate, slightly emarginate, or slightly rounded; colorful Indo-Pacific species of moderate size (some attaining 300 mm. in standard length).

[1] Contribution no. 195 from the Marine Laboratory, University of Miami.

[2] Jordan and Snyder (1902: 628) proposed *Ampheces* as a subgenus for the species *Anampses geographicus* Cuvier and Valenciennes; *Pseudanampses* Bleeker (1862: 101), however, has priority.

KEY TO THE HAWAIIAN SPECIES OF ANAMPSES

1a. Body relatively deep, depth contained about 2.5 to 2.8 times in standard length; caudal fin truncate 2

1b. Body not deep, depth contained about 3.3 to 4 times in standard length; caudal fin slightly rounded in adults 3

2a. Each scale of body with a prominent round white spot ..... *Anampses cuvieri* (Fig. 1)

2b. Each scale of body with a narrow vertical blue line ..... *Anampses godeffroyi* (Fig. 2)

3a. Body without white spots; head pale (bright orange in life with blue bands) and contrasting sharply with darker body; caudal fin not paler than body. *Anampses chrysocephalus*, n. sp. (Fig. 3)

3b. Body with white spots (one per scale below lateral line, several per scale above); head not paler than body; caudal fin markedly paler than body (in life red distally and white basally). *Anampses rubrocaudatus*, n. sp. (Fig. 4)

Anampses chrysocephalus, n. sp.

Fig. 3

Holotype.—U.S.N.M. no 164465, a male, 151.5 mm in standard length and 181.5 mm in total length, obtained by J. Randall on June 19, 1953, from a fisherman whose traps were set in about 30 to 90 feet of water from Kewalo Basin to Koko Head, Oahu, Territory of Hawaii.

Paratype.—University of Hawaii no. 2152, a male specimen, 139.5 mm in standard length and 168.5 mm in total length, obtained by W. Gosline in January 1950 from the Honolulu Aquarium.

The majority of the aquarium fishes are purchased from trap fishermen. The specimen is in poor condition. It was preserved after being discovered dead on the bottom; sufficient time had elapsed for partial decomposition to occur.

Description.—Based on the holotype and one paratype. Counts and measurements are recorded for the holotype, followed in parentheses by data for the paratype if different from that of the holotype. Measurements were not made of the fins of the paratype.

Dorsal fin rays IX,12; anal fin rays III,12] pectoral fin rays 13 (the uppermost rudimentary, the next unbranched); pelvic fin rays I,5; principal caudal rays 14. Lateral line scales 28, 19 in the anterior part, 2 in the part which is bent sharply downward at the level of the ninth dorsal soft ray, and 7 in the peduncular part; a single row of large scales between anterior part of lateral line and dorsal fin and 7 rows between anterior part of lateral line and anal fin (a few small scales occur between the uppermost and lowermost rows of body scales and the dorsal and anal fins, respectively; however no scales are present basally on these fins); a patch of small scales basally on caudal fin posterior to large body scales; head naked; small scales on nape poorly developed or imbedded; triangular area from isthmus to upper base of pectoral fin and origin of pelvic fins covered with small distinct scales; gill rakers on first gill arch 13 (paratype only).

Head length 2.96 (2.90); depth of body 3.36 (3.34); snout to anus 1.83 (1.81); snout to origin of pelvic fins 2.64 (2.58); snout to origin of dorsal fin 3.21 (3.03); length of dorsal fin base 1.56 (1.55); length of anal fin base 2.53 (2.54)—all in standard length.

Width of body at gill opening 2.43 (2.64); least depth of caudal peduncle 2.59 (2.69); snout length 2.80 (2.75); diameter of eye 7.10 (6.89); width of interorbital 3.93 (4.00); length of pectoral fin 2.22 (fins frayed on either side, thus probably shorter than normal); length of pelvic fin 1.82; width of mouth (rictus to rictus) 5.68 (5.44); mid-center of upper lip to most posterior part of upper lip 6.01 (6.02); edge of eye to upper end of free margin of preopercle 7.35 (7.39); first dorsal spine 7.63; second dorsal spine 5.38; ninth dorsal spine 3.29; first dorsal soft ray 2.79; first anal spine 12.2; second anal spine 6.96; third anal spine 5.16; first anal soft ray 3.06—all in head length.

Profile of head with a slight indentation just anterior to a vertical through forward edge of eye; lips moderately fleshy; dentition characteristic of the genus, the length of the upper pair of incisors 2.2 in eye diameter, that of the lower pair 3.2 in eye diameter; upper teeth nearly touching at their base; space between lower pair of teeth contained about 3 times in eye diameter (no other teeth could be found in the jaws—only a bony plate which is exposed when the lips are pulled outward); a well-developed opercular flap, its length posterior to opercle equal to eye diameter; gill membranes attached to isthmus with a small free fold across it dorsal and anal spines slender but pungent; posterodistal ends of dorsal and anal fins pointed; caudal fin slightly rounded.

Color in alcohol: head light tan, almost white with irregular, dark-edged, light bluish-gray bands and spots; a large black spot on membranous opercular flap; body brown, the center of each scale darker than the edges; an elongate, lobed, dark-edged, bluish-gray spot on nape extending across demarcation of pale head and brown body, the part on the body partially surrounded by a narrow pale region (this region continuous with a middorsal pale band about an eye diameter in width which extends anteriorly from origin of dorsal fin); dorsal fin dark brown with a distinct but narrow white margin; anal fin brown, shading outwardly to light yellowish brown, with a narrow pale margin, a thin submarginal dark line, and pale blue blotches (there is a large elongate blotch basally on each interradial membrane and a lesser spot or spots distal to the large one); caudal fin dark brown; pelvic fin rays brown, the membranes pale; pectoral fin pale, brown at extreme base; a pale spot on upper part of axil of pectoral fin.

In life the head was brilliant orange with black-edged, iridescent blue bands and spots; body dark orangish brown with a vertically elongate grayish green spot on posterior border of each scale; lobed blue spot on nape surrounded by a narrow bright lemon yellow area which is continuous with a yellow middorsal band on nape; lips and adjacent portion of snout light tan; dorsal and caudal fins dark brown, the dorsal with a narrow white margin; anal fin brown, shading in outer part to yellow, with blue blotches, a narrow white margin, and a thin dark brown submarginal line; pectoral fin hyaline, dark brown at base; axil of pectoral blue dorsally

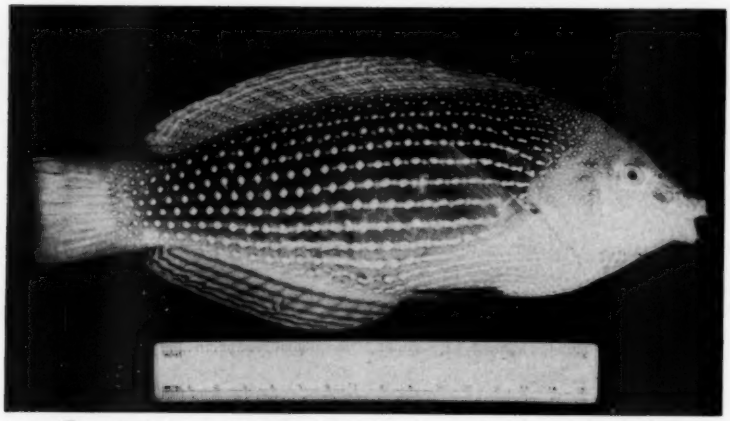

FIG. 1.—*Anampses cuvieri* Quoy and Gaimard: From a 35-mm color transparency of a fresh specimen. Standard length, 210 mm.

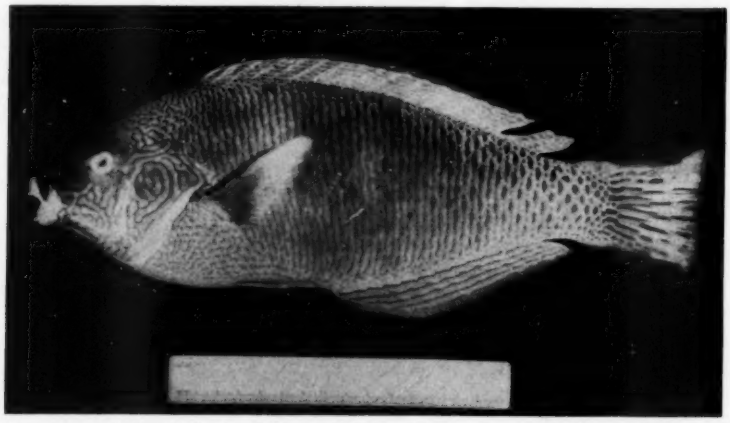

FIG. 2.—*Anampses godeffroyi* Günther: From a 35-mm color transparency of a fresh specimen. Dorsal fin split. Standard length, 268 mm.

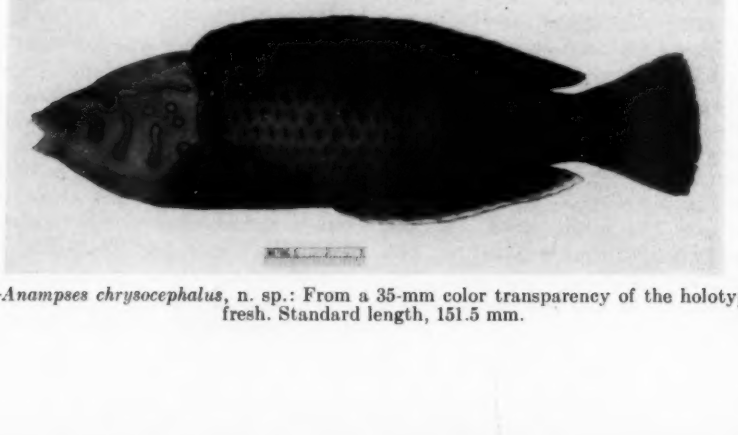

FIG. 3.—*Anampses chrysocephalus*, n. sp.: From a 35-mm color transparency of the holotype when fresh. Standard length, 151.5 mm.

FIG. 4.—*Anampses rubrocaudatus*, n. sp.: From a photograph of the holotype after preservation by W. Courtenay. Pectorals abraded and injury evident on back at rear base of dorsal. Standard length, 137.7 mm.

orange in midsection, shading to pale lavender ventrally.

Vernon E. Brock, director of the Division of Fish and Game of the Territory of Hawaii, has informed me that he has observed *Anampses chrysocephalus* to be moderately common at depths of about 100 feet on the Waianae coast, Oahu.

Named *chrysocephalus* (Greek χρυσός, gold; κεφαλή, head) in reference to the striking coloration of the head.

Of the species of *Anampses*, *A. chrysocephalus* appears to be most closely related to *A. melanurus* Bleeker, also an elongate species with a black spot on the opercular membrane. *A. chrysocephalus* is distinct from *melanurus* in its smaller eye, shorter third anal spine relative to longest dorsal spine, and color. Instead of a pale head with darker irregular spots, *melanurus* has a dark head with light spots; also *melanurus* has a spotted dorsal fin and a light caudal fin with a broad dark subterminal vertical band (after de Beaufort, 1940: 103, no specimens seen by me).

Anampses rubrocaudatus, n. sp.
Fig. 4

Holotype.—U.S.N.M. no. 160624, a female, 137.7 mm in standard length and 166 mm in total length, obtained from S. Tinker of the Honolulu Aquarium, Oahu, Territory of Hawaii, 1950.

Paratype.—University of Hawaii no. 2291, 82.6 mm in standard length and 108.5 mm in total length, collected by personnel of the Division of Fish and Game, Territory of Hawaii, by spearing off Waianae, Oahu, at a depth of about 90 feet, in 1956.

Description.—Based on the holotype and one paratype. Counts and measurements are recorded for the holotype, followed in parentheses by data for the paratype if different from that of the holotype.

Dorsal fin rays IX,12; anal fin rays III,12; pectoral fin rays 13 (outer portion of fins absent in holotype); pelvic fin rays I,5; principal caudal rays 14. Lateral line scales 28, 19 in anterior portion, 2 in part which angles downward at level of base of ninth dorsal soft ray, and 7 in peduncular part; a single row of large scales above lateral line (above this a second row about one-half as large, and between the latter row and the dorsal fin a few small scales, these more numerous anteriorly); 8 rows of large scales below lateral line to origin of anal fin (plus a few small scales next to fin); 7 large scale rows between lateral line and more posterior part of anal fin; small scales present on base of caudal fin, thorax, and ventral part of abdomen; no median predorsal scales, but a few small imbedded scales more laterally on nape; head naked; gill rakers on first arch 20 (holotype only).

Head length 2.86 (2.98); depth of body 3.29 (3.95); snout to anus 1.86 (paratype not measured); snout to origin of pelvic fins 2.73 (paratype not measured); snout to origin of dorsal fin 2.98 (paratype not measured); length of dorsal fin base 1.58 (1.62); length of anal fin base 2.60 (2.95)—all in standard length.

Width of body at gill opening 2.46 (2.77); least depth of caudal peduncle 2.69 (3.11); snout length 3.12 (3.34); diameter of eye 7.17 (5.32); width of interorbital 3.93 (4.62); length of pectoral fin 1.80 (paratype only); length of pelvic fin 1.77 (2.18); width of mouth (rictus to

rictus) 5.11 (6.93); mid-center of upper lip to most posterior part of upper lip 5.16 (5.04); edge of eye to upper end of free margin of preopercle 7.17 (paratype not measured); first dorsal spine 8.00 (7.78); second dorsal spine 5.51 (paratype not measured); ninth dorsal spine 3.20 (3.30); first dorsal soft ray 2.40 (2.91); first anal spine 9.60 (10.6); second anal spine 6.00 (8.70); third anal spine 4.70 (4.95); first anal soft ray 2.74 (2.98)—all in head length.

Profile of head smooth; lips fleshy, the edges rounded and firm; no membranous flap extending from ethmoidal part of snout over groove posterior to upper lip to rest on base of upper lip; dentition characteristic of genus, the length of the incisors of the holotype 2.6 mm; upper incisors of holotype separated by 1.7 mm and lowers by 0.7 mm; a well-developed opercular flap, its length posterior to opercle equal to eye diameter; gill membranes attached to isthmus with a small free fold across it; dorsal and anal spines flexible in holotype, pungent in paratype; posterodistal ends of dorsal and anal fins pointed; caudal fin slightly rounded.

Color in alcohol: dark brown (the head of the paratype a little darker than the body) with a white spot in center of each scale below the lateral line; scales in lateral line and above lateral line with about 4 to 6 white spots; head with numerous small white spots, those on snout, interorbital, and nape very small and close-set; unscaled portion of caudal fin white; dorsal fin brown with numerous small white spots and a white border; anal fin dark brown with a few scattered faint white dots, especially at base, and a very narrow white margin; pectoral fins white, the base brown with white spots; pelvic fins with a broad brown lateral edge, light brown rays, and hyaline membranes; lips whitish, the base of the upper lip light brown with small white spots.

Life color of the holotype of *A. rubrocaudatus* from a 35-mm color transparency on file in the United States National Museum: Dark chocolate brown with white spots; outer half of caudal fin bright red, basal half white; pectoral pink; lips pinkish; inner portion of iris orange-yellow.

Like *A. chrysocephalus*, this species appears to be restricted to moderate depths on Hawaiian reefs.

Named *rubrocaudatus* (Latin *rubro*, combining form of *ruber*, red; *caudatus*, tailed) in reference to the prominent red color on the outer half of the caudal fin.

This species is most closely allied to *Anampses meleagrides* Cuvier and Valenciennes, known from East Africa to the East Indies, Philippines, Riu Kiu Islands, and possibly Japan (the species *Anampses ikedae* and *A. nagoyoi* described by Tanaka from Kagoshima, Japan, may be synonyms of *A. meleagrides*). The similarity is so great that it seems probable that *meleagrides* gave rise through isolation in Hawaii to *rubrocaudatus*. *A. rubrocaudatus* differs from *meleagrides* in having a larger mouth (the width of the mouth of the 137.7 mm holotype measures 9.3 mm; of a 136-mm Philippine specimen of *meleagrides* 6 mm; the length of the upper jaw of *rubrocaudatus* is 10.7 mm, of the *meleagrides* specimen, 8.7 mm); lips which are more fleshy and firm (the edges of the lips of *meleagrides* are thin and supple); lacking a frenum extending from the ethmoidal part of the snout over the groove posterior to the upper lip and overlapping the basal part of the upper lip (this flap in *meleagrides* makes the lips seem even smaller than they actually are), having a slightly rounded instead of slightly emarginate caudal fin, and color as follows: several white spots per scale in lateral line and above (single spot per scale in *meleagrides*); spots on head and on dorsal fin smaller and more numerous; spots on anal fin tiny and indistinct; lips pale (brownish in *meleagrides*); no white line at base of pectoral fins as in *meleagrides*; caudal fin red and white in life (yellow in life in *meleagrides*).

A. meleagrides may have a white-edged black spot posteriorly on the dorsal and anal fins. Insufficient specimens have been examined to determine if this is a juvenile or sexual character. It appears to be a juvenile character in *Anampses cuvieri* Quoy and Gaimard from the Hawaiian Islands. A specimen 46 mm in standard length has a prominent ocellated black spot on the hind part of the dorsal and anal fins; on a 70-mm specimen the anal ocellus is gone and the dorsal ocellus just disappearing.

As indicated in the key, the four Hawaiian species of *Anampses* are easily distinguished one from another, although color characters, of necessity, have been emphasized.

Both *A. cuvieri* and *A. godeffroyi* Günther[3] are portrayed in color in Günther's Fische der Südsee

[3] As was suspected by Jordan and Evermann (1905: 294) and Jordan and Seale (1906: 296), *Anampses evermanni* Jenkins is a synonym of *A. godeffroyi*.

(1881: pls. 136 A and 140, respectively), although somewhat inaccurately. The spots on the body of *A. cuvieri* should be white instead of blue. *A. godeffroyi* is depicted as pale blue with a vertical blue line on each scale and numerous irregular dark blue markings on the head. The true life color (as based on a specimen 268 mm in standard length from Hawaii) is as follows: Body grayish brown with vertical blue lines on scales; anterodorsal quadrant of head (enclosing eye) bright green; remainder of head grayish brown with tortuous, narrow, dark blue lines, those on nape small and not interconnected; dorsal and anal fins brownish gray with prominent bright blue margins and narrow lengthwise dark blue lines; caudal fin colored like body on basal half, orange-yellow on outer half, with short horizontal blue lines and broad blue upper and lower margins; pectoral fin grayish brown on basal half and orange-yellow on outer half, with a blue line on upper margin; iris red and the lips flesh-colored.

Previously *A. godeffroyi* was known only from the Hawaiian Islands, except for one uncertain record from the Society Islands by Fowler (1928: 332) based on two specimens in the Museum of Comparative Zoology. Of these Fowler wrote, "Though dark and vertical lines little distinct these specimens evidently this species, not previously known, from outside Hawaii." I have recently collected this species from the Society Islands and Tuamotu Archipelago and can thus verify Fowler's record. Specimens are catalogued at the United States National Museum under the number 164602 and at the Natural History Museum, Stanford University, under the number 48870. In French Oceania this wrasse was observed only in relatively shallow (generally less than 20 feet) outer reef areas exposed to the action of surf. On several occasions while I was attempting to spear individuals of this species, they retreated to the inshore ends of surge channels and disappeared in the white water of the surf. In Hawaii the species is usually seen in deeper, less turbulent water.

A. godeffroyi has a vertical blue line on each scale of the body in the Society Islands as in Hawaii; however, there are some differences in color between the species in the two island groups. The life colors of a 200 mm specimen from Tahiti are as follows: Body iridescent greenish brown, the edges of the scales dark olive, with a vertical bright blue narrow line on each scale except on the nape, thorax, abdomen, and scaled portion of caudal fin, where blue spots replace the blue lines (ground color on abdomen purplish and on thorax pale turquoise); head dull olive-green, purplish on opercle, shading to pale turquoise ventrally with widely spaced narrow bright blue lines, two of which are nearly horizontal and run from snout through eye almost to end of opercle; dorsal fin greenish yellow basally, shading to copper up to the blue margin (which occupies about one-tenth the width of the fin), with about three irregular rows of small blue spots; anal similar to dorsal, but with a broader blue margin (about one-fourth width of fin); caudal fin with broad bright blue upper and lower margins and eight blue horizontal bars interspersed with orangish areas; upper edge of pectoral fin blue, then a region of hyaline copper shading to pale yellow on lower part of fin; pelvic fins blue-edged with a median blue band separating lateral copper and medial pale yellow areas; iris yellow with shades of iridescent green. A color marking readily seen underwater on the species but not noticeable when the fish are removed from the water is a light greenish area dorsally on caudal peduncle.

The most notable differences of the Society Islands specimens from the Hawaiian are the discrete instead of interconnected blue lines on the head, the lack of the anterodorsal green area on the head, and rows of small spots on the dorsal and anal fins instead of solid blue lines. In view of the similarity of the two forms, the differences mentioned are believed to be subspecific and not specific in magnitude.

As might be expected from the isolation of the Hawaiian Islands, due not only to distance but also to the direction of ocean currents, minor color differences are frequently seen between a species of reef fish in Hawaii and elsewhere in the Indo-Pacific area. In some species the color differences are not so minor and may be coupled with differences in counts or proportional measurements. A point is reached where a taxonomist feels impelled to recognize the Hawaiian form as a distinct species. Unfortunately, opinions vary as to the degree of differentiation necessary to establish a species in Hawaii as distinct. This problem, of course, is not confined to Hawaii and the tropical Pacific, but I shall restrict the present discussion to this area. Some authors, to give but a few examples, regard *Chromis dimidiatus* (Klunzinger), *Macro-*

pharyngodon geoffroy (Quoy and Gaimard), and *Acanthurus triostegus* (Linnaeus) in Hawaii as not specifically different from these species elsewhere in their range, whereas others recognize them as full species by the names *C. leucurus* Gilbert, *M. meleagris* (Cuvier and Valenciennes), and *A. sandvicensis* Streets (for details of these species pairs, see Randall, 1955 and 1956). Some authors have preferred to regard a Hawaiian form as a full species when a character, even if only a small spot of color, provides complete separation of the Hawaiian material from that elsewhere in Oceania. Since no insular stepping stones join the Hawaiian chain with islands to the south and west, it is not possible to demonstrate typical subspecific integradation at some intermediate place; but this does not mean that the subspecific concept cannot be applied. I do not agree with Gosline (1955: 469) who wrote, "It was felt that intergradation between the Hawaiian endemics and their Central Pacific counterparts would occur at Johnston if anywhere. If does not occur there (or elsewhere among any of the fishes here investigated, and on the basis of absence of intergradation (the term is here used in contrast with introgression) the Hawaiian endemics must be considered full species." As this author has indicated (p. 479), the Johnston Island fish fauna is essentially Hawaiian (as its proximity to Hawaii would suggest); therefore I do not believe the absence of intergradation at Johnston is a strong indication of full specific rank of the Hawaiian forms in question. There does not seem to be equal opportunity for the Central Pacific counterparts to meet the Hawaiian forms at Johnston. In my opinion the best criterion on which to base the assigning of a name to a Hawaiian variant consists of drawing inferences from the degree of differentiation of other closely related species in the same genus (if they exist) which occur together. Naturally this is imperfect, for a Hawaiian form, although distinguished morphologically only slightly, or perhaps not at all, from the species in non-Hawaiian areas, may have differentiated physiologically or ecologically such that natural interbreeding would be impossible.

As long as the morphological differences between Hawaiian and related non-Hawaiian forms are noted, it might be argued that it is unimportant whether opinions differ as to how to recognize them nomenclatorially. In a sense this is true; however I believe the conservative approach (namely, the recognition of the Hawaiian forms as subspecies or varieties when differences are slight, even though constant) is preferred, for it results in fewer specific names with which to contend and is less misleading from a zoogeographical standpoint.

Anampses cuvieri is known only from the Hawaiian Islands where, like many of the endemic fishes, it is abundant. The common *Anampses caeruleopunctatus* Rüppell is in continuous distribution from the Red Sea and east Africa eastward throughout all Oceania except Hawaii.[4] These two species are very closely related. Their similarity first became apparent to the writer when the life colors of *caeruleopunctatus* were noted in collections from the Society Islands, Tuamotus, and Marquesas (the species is previously unrecorded from the latter two island groups; specimens have been deposited in the United States National Museum, and Natural History Museum at Stanford University). A 180-mm specimen from Tahiti was olive, shading to reddish ventrally, the edges of the scales darker, with a single bright blue spot, edged in blackish, in the center of each scale; head marked with similar spots and dark-edged blue bands (more bands and fewer spots on large specimens); dorsal fin dark copper with narrow bright blue margin, dark submarginal line, and approximately three rows of small dark-edged blue spots; anal fin bright red with a margin like the dorsal and two rows of small dark-edged blue spots, one at the base and one half way out in fin; caudal fin dark reddish brown with blue edges and blue spots as on body but slightly larger; pectoral fins hyaline with pale yellow rays; pelvic fins red with blue lateral edge and two blue blotches; lips reddish. *A. caeruleopunctatus* differs from *A. cuvieri* in having blue instead of white spots, in lacking small intermediate spots between some of the larger ones centered in each body scale (this giving more of a linear effect on *cuvieri*), in having principally blue bands on the head instead of small spots, in having a spotted caudal fin and rows of spots instead of solid lines in the dorsal and anal fins; the dorsal and anal fins are pointed posteriorly in *caeruleopunctatus* and slightly rounded in *cuvieri*; *caeruleopunctatus* (Society Islands and Tuamotus) has 21 or 22 gill rakers on the first

[4] The two specimens of *A. caeruleopunctatus* (U.S.N.M. no. 71657) listed from Japan by Fowler and Bean (1928: 230) were collected in Okinawa, Riu Kiu Islands. Kamohara (1954: 46, fig. 11) has recorded the species from Japan.

gill arch and *cuvieri* 19 or 20. The above differences are probably great enough to warrant the recognition of two species, but the similarity in other characters and the distribution of the species suggests that *caeruleopunctatus* may have been the progenitor stock which gave rise through independent evolution of a Hawaiian population to *A. cuvieri*.

Although Fowler (1928: 333) correctly placed *Anampses pulcher* Regan from Easter Island in the synonymy of *caeruleopunctatus*, he created another synonym when he described *Anampses tinkhami* from the Riu Kiu Islands (1946: 162). Dr. James E. Böhlke provided the author with information on the type of *A. tinkhami* in the Academy of Natural Sciences of Philadelphia.

Another species of *Anampses*, *A. twistii* Bleeker, with a type locality of Ambon, East Indies, was collected in the Society Islands and was sighted in the pass at the atoll of Takaroa in the Tuamotu Archipelago. Previously this species was known from the central Pacific from one 80-mm specimen taken at Fiji (as *Anampses fidjensis* Sauvage, 1880: 224). Dr. Leonard P. Schultz, of the United States National Museum, will record the species from the northern Marshall Islands in volume 2 of *Fishes of the Marshall and Marianas Islands*. Recently Kamohara (*op. cit.*) has recorded it from Japan and Smith (1955: 931) from the western Indian Ocean. The Society Islands specimen was taken with a spear in the lagoon of Moorea at a depth of 40 feet. It measures 83 mm in standard length, and is catalogued in the United States National Museum under number 114743. In life the fish was purple on most of the body and upper half of the head; the lower half of the head and the thorax up to the pectoral base was yellow (the demarcation between purple and yellow being gradual, not abrupt); body and nape covered with small, black-edged blue spots (few, however, occurring on thoracic region); caudal peduncle and caudal fin dull orange-red with a broad whitish posterior margin and small pale blue spots (spots lacking on outer third of fin); dorsal and anal fins reddish purple, shading to copper distally and posteriorly (the anal with shades of yellow anteriorly in middle of fin), with small dark-edged blue spots and a conspicuous blue-edged black spot, in diameter nearly twice as great as eye, in the posterior part of each fin; dorsal and anal fins margined narrowly with blue anteriorly and black posteriorly; paired fins yellow, the pectorals with a dark brown band at the base; opercular membrane darker than rest of head; lips orangish white. The body depth of the specimen is contained 3.3 times in the standard length; the upper pair of canine teeth are sharply upcurved and the lowers sharply downcurved. Individuals of the species nearly twice as large as this specimen were seen in the same area, as were juveniles. The blue spots on the latter were fewer and larger, and the bright yellow ventral coloration was lacking.

Specimens of the non-Hawaiian species, *Anampses diadematus* Rüppell, *A. amboinensis* Bleeker, *A. geographicus* Cuvier and Valenciennes, and *A. pterophthalmus* Bleeker were examined at the United States National Museum and the Natural History Museum, Stanford University. *A. diadematus* is suggestive of *godeffroyi* in having vertical pale lines on the scales and similar body proportions. It differs primarily in having predorsal scales (absent mid-dorsally on *godeffroyi*) and in possessing a distinctive pale band running forward from the eye across the front part of the interorbital space and a second, narrower band connecting eyes vertically across the interorbital.

A. pterophthalmus and *A. geographicus* differ from all other *Anampses* in having much higher scale counts (lateral line scales given by de Beaufort, *op. cit.* as 49–51). These two species differ from one another only in color and caudal fin shape, and it is believed that the former is the female and subadult male of the latter, although more specimens are needed to demonstrate this conclusively. *A. geographicus* is the older name. Mostly females and a few males were found among the museum specimens of *pterophthalmus* which could be sexed. The largest specimen is 166.5 mm in standard length. Seven males and no females were identified among 16 specimens of *geographicus* which could be sexed. With the exception of one disconcerting 107-mm specimen (sex indeterminable) the *geographicus* ranged from 150 to 199 mm in standard length. *A. pterophthalmus* has a truncate caudal fin and a large, black, white-edged spot posteriorly in the dorsal and anal fins. Except for the 107-mm specimen which has a truncate caudal fin, all of the *geographicus* have emarginate caudal fins with slightly produced lobes. *A. geographicus* is a more colorful species, has a vermiculation of narrow bands on the head and chest, and ordinarily lacks ocelli in the fins. Fowler and Bean (*op. cit.*: 227) recorded one specimen from Cebu, Philippine Islands, with

obscure ocelli on the last dorsal and anal rays. The specimen is 152 mm in standard length, and its caudal fin is slightly emarginate. This fish appears to be transforming from the *pterophthalmus* form to that of *geographicus*.

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COCKROACHES AND DISEASE

Cockroaches are highly dangerous potential carriers of human disease. This is stressed in a report by Drs. Louis M. Roth and Edwin R. Willis, of the Quartermaster Research and Engineering Center, recently issued by the Smithsonian Institution. At least 18 species of cockroaches known to inhabit houses have been incriminated, naturally or experimentally, in transmission of infectious agents, or have been claimed to bite man. Several of the commonest species have been captured repeatedly in sewers, cesspools, and septic tanks and have been found migrating from sewers and dumps into nearby buildings. The predilection of cockroaches for human food is notorious. Thus, the two scientists point out, the mechanism certainly exists for transference of disease organisms to man and domestic animals.

Natural transmission has not, however, been incontrovertibly proved. Four strains of polio virus, however, have been found occurring naturally in wild-caught cockroaches. In addition they can harbor, experimentally, Coxsackie, mouse encephalomyelitis, and yellow-fever viruses. About 40 species of disease-causing bacteria have been isolated from naturally contaminated cockroaches, and two species of fungi that have been associated with human maladies have been found.

"There is no question," say the Quartermaster Corps scientists, "about the ability of cockroaches to carry pathogens in or on their bodies. . . Although they undoubtedly are vectors of the agents of viral and bacterial diseases, with very few exceptions their relations to specific outbreaks of disease have not been determined. This area of research has not received the attention it deserves. Demonstrating correlations between house flies and incidence of intestinal disease has been difficult. Linking cockroaches with the actual transmission of similar disease agents will be no easier.

"Cockroaches are tough, resilient insects with amazing endurance and ability to recover rapidly from almost complete extermination. They will probably always be with us, and we can only temporarily reduce their numbers. But, as in all battles, recognition of a common enemy is essential to successful combat."